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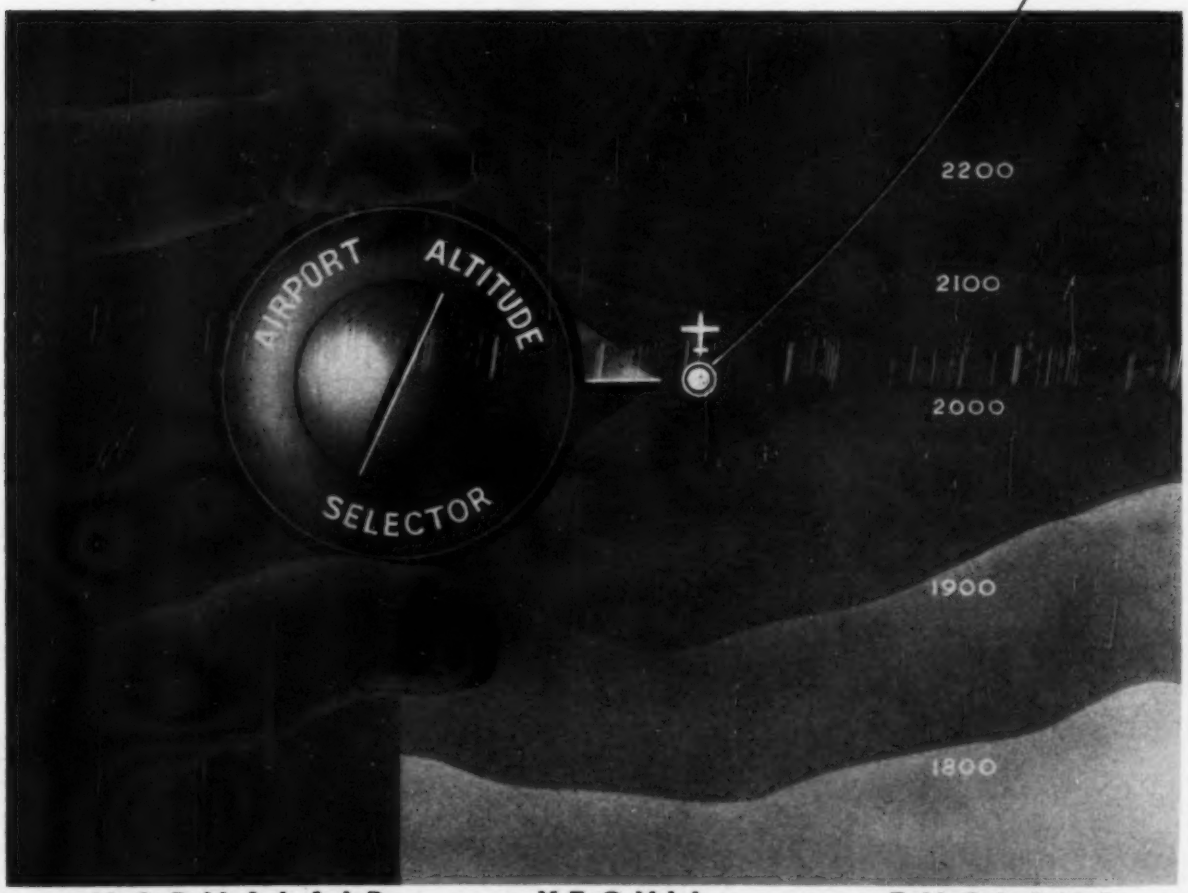

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A

Around the World

JETS' TEST DIET

Pratt & Whitney Aircraft's dependable JT3 and JT4 jet engines underwent a series of grueling tests before they could be certificated by the U.S. Civil Aeronautics Administration for use in commercial airliners. They demonstrated the ability to absorb without serious damage such items as lunch pails, rocks, tools, clothing, a variety of fowl and other material. A group of such items, typical of those ingested, are displayed here. Arrow points to 2-inch ice balls fired into the engines' compressor at speeds up to 600 mph, in a simulated severe hailstorm. Airlines around the world have ordered more than 1800 JT3 and JT4 engines for Boeing 707 and Douglas DC-8 airliners.

LARGE PLANT ADDED—A 410,000 square-foot plant addition (circled) is now in operation at Hamilton Standard's main plant in Windsor Locks, Connecticut. The new area is devoted chiefly to engineering and production work on jet engine fuel controls. Hamilton Standard fuel controls are being supplied for all Boeing 707 and Douglas DC-8 jet transports with Pratt & Whitney Aircraft power plants, and for 10 other types of aircraft. Hamilton Standard also recently announced its expansion into the field of aviation electronics.

with United Aircraft

JUNGLE OIL AIRLIFT

Sikorsky S-58 helicopters with 4000-pound payload capacity recently pioneered a far-reaching, new technique in oil drilling operations. They flew all necessary construction equipment, drilling rigs, men and supplies to scattered well sites in jungle areas of wild, mountainous New Guinea, then supported the drilling operations. Costly, time-consuming road construction was not necessary, and only a few months were needed to do the entire rig emplacement job by S-58. It is estimated 18 months would have been needed if ordinary surface transportation had been used. Pictured above, an S-58 brings in a heavy iron skid for a drilling rig engine. At right, an S-58 lands supplies at a drill rig which itself was flown to the site in sections by S-58.

UNITED AIRCRAFT EXPORT CORPORATION *East Hartford 8, Connecticut, U. S. A.*

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Fairey "Gannet", the most advanced concept of an anti-submarine aircraft in the world, is in service with the Royal Navy and the Royal Australian Navy and has been ordered for Western Germany's Naval Air Arm. Materials for the construction of this aircraft are supplied by British Aluminium.

The BRITISH ALUMINIUM Co Ltd

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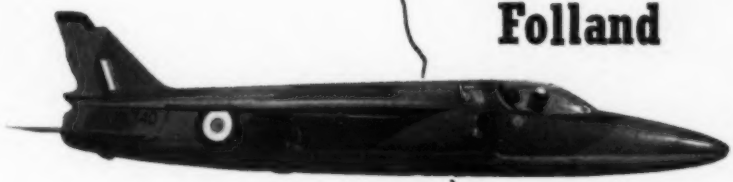
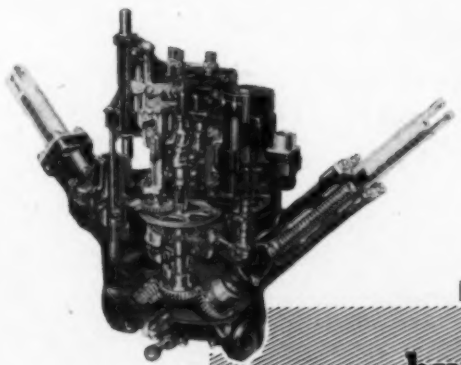
A.P.84

Power Flying Controls for the Folland 'Gnat'





The Hobson Type 145 Power Flying Control is an irreversible twin-screw jack featuring hydraulic primary drive, and electric trimming and emergency drive. It is self-locking in the event of supply failure in either source and, from the safety aspect, is eminently suitable for a single-engined aeroplane where duplication of hydraulic supply is difficult to arrange.

The unit, as illustrated, is typical of that fitted to the Folland "Gnat" to meet specific aircraft requirements, and is one of many piston and screw-jack type controls designed and manufactured . . .

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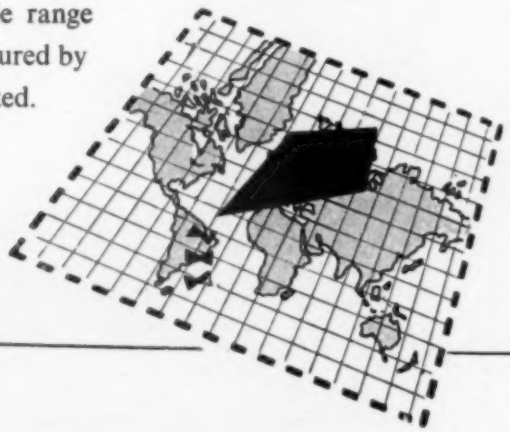

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Hymatic PS 60 valves are supplied for the Folland Gnat aircraft

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DEFENCE WHITE PAPER APRIL, 1957.

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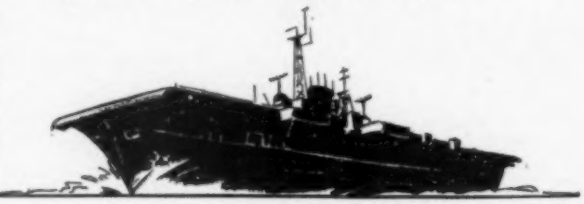

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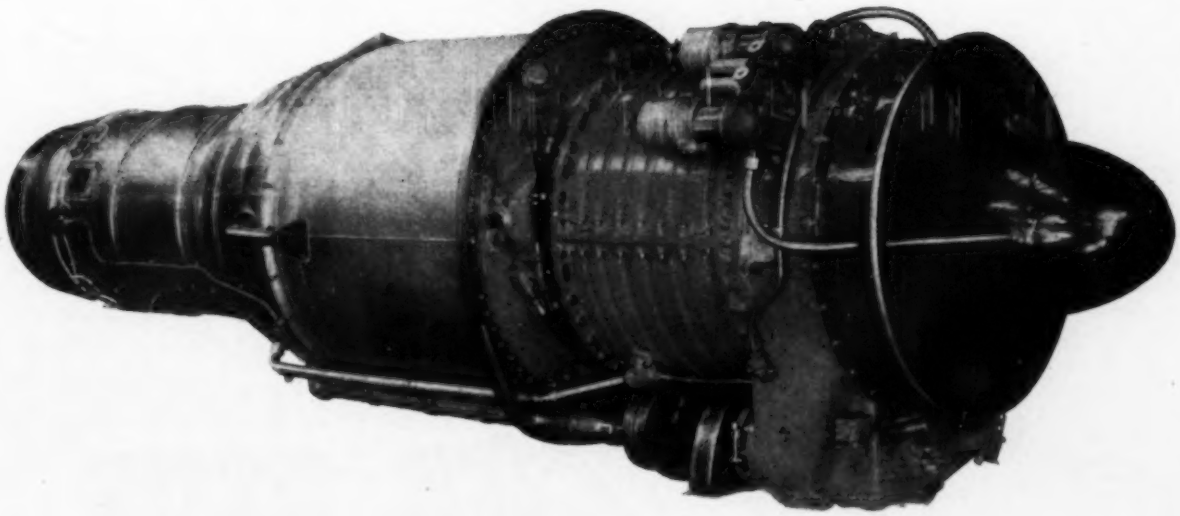

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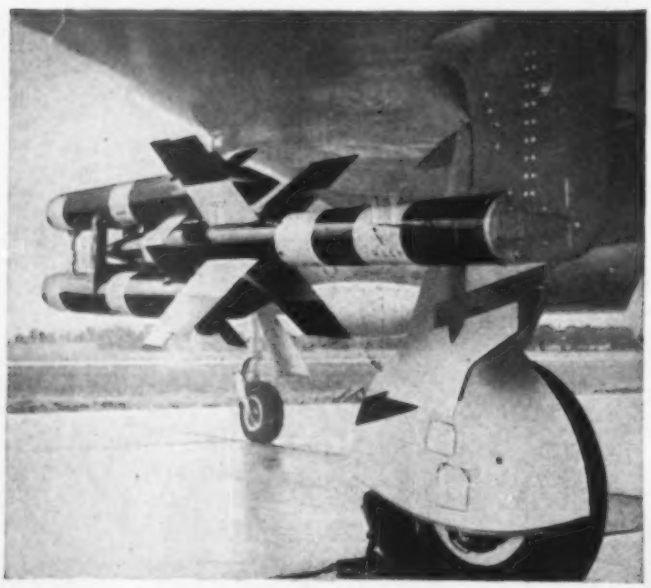

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5% Al., 2½% Sn.	46.0	56.0	18.0	270
2% Mn. 2% Al.	36.0	44.0	20.0	240
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The fantastic strides that are being made in the development of the rocket have brought the dream of space travel into the realm of man's future conquest. The design and development groups of Helliwells have already achieved much in their research into the special problems of rocket airframe components. It may well be that, just as the passengers in the Bristol Britannia of today rest on sleeping berth frames built at Elmdon, the passengers of the future, too, will depend for their comfort and safety on the imagination and skill of the men at Helliwells —"They who look ahead".

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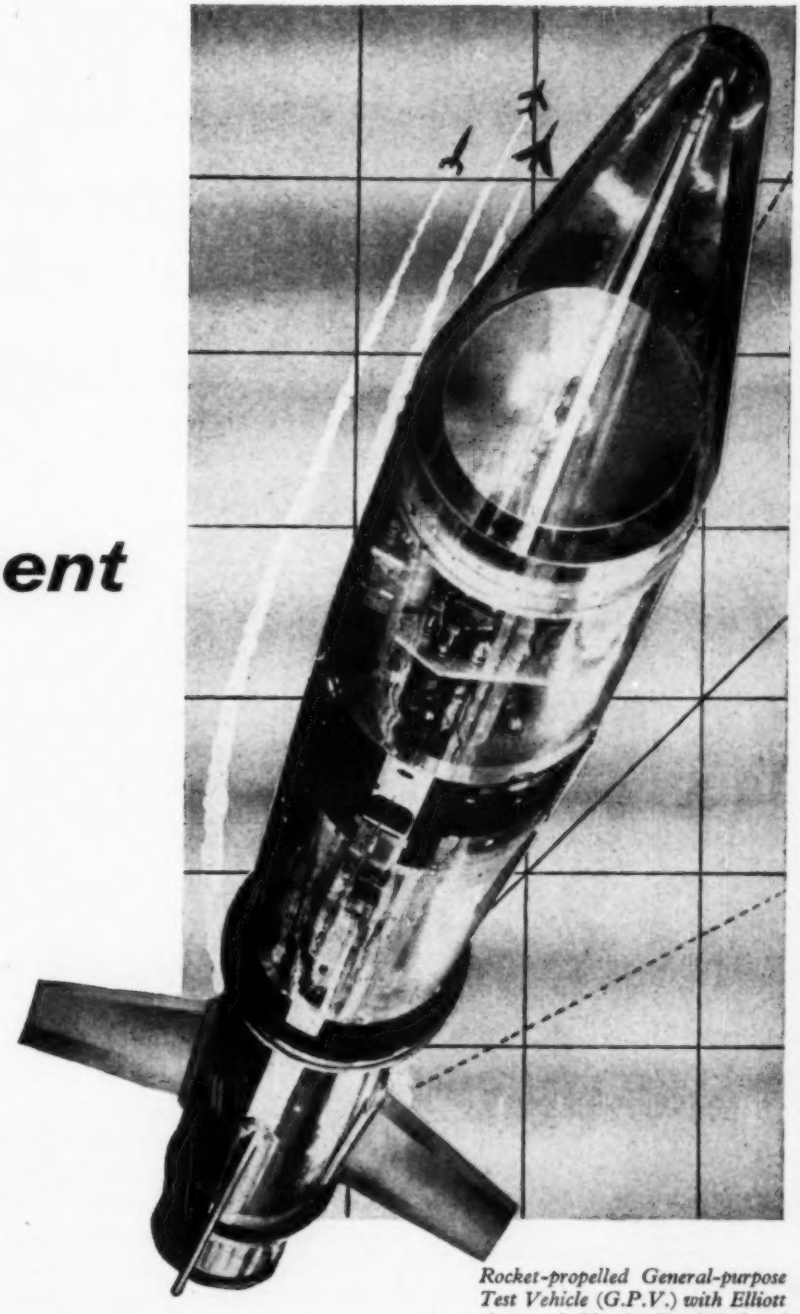
Progress in the development of Homing Systems



Rocket-propelled General-purpose Test Vehicle (G.P.V.) with Elliott Automatic Homing Head displayed at S.B.A.C., Farnborough, 1957

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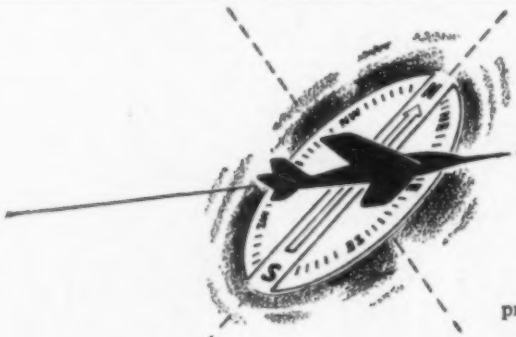

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'Flight' photograph

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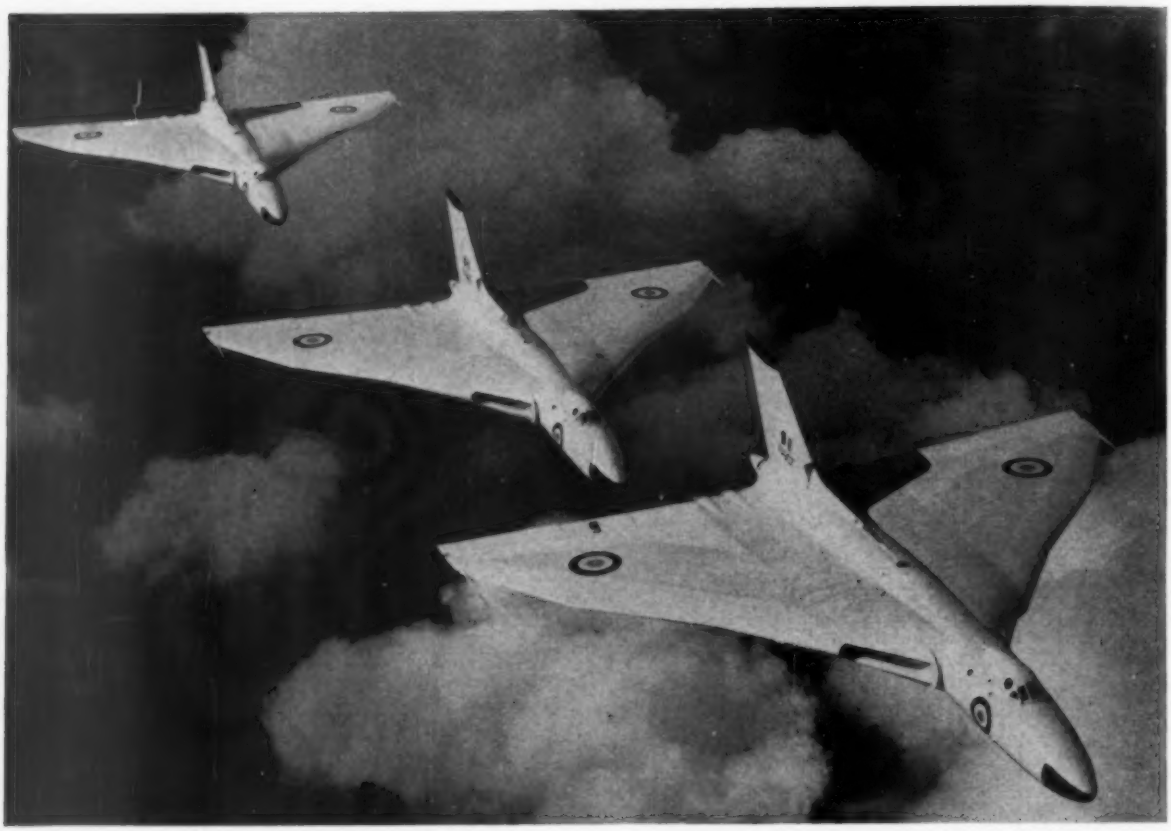

"Equal to, if not better than, any Bomber in the World"

—Mr. C. I. Orr-Ewing, Under Secretary for Air.

In announcing that the famous 617 Squadron—the Dam Busters—is to be reformed and equipped with the Avro Vulcan Delta Bomber, believed to be the fastest bomber in service anywhere, Mr. Charles Ian Orr-Ewing, Under Secretary for Air, has said that in the Vulcan "we now have a bomber aircraft which is equal to, if not better than, anything else in the world".

"The Vulcan comes from a good stable"

In addition to Mr. Orr-Ewing's tribute, the Air Officer Commanding No. 1 Group, Bomber Command, had this to say: "We are extremely pleased with the Vulcan, both from the operating and the maintenance aspects. The way in which this large aircraft and its complex system has been brought into use in the front line of Bomber Command, without any of the enforced groundings so frequently experienced with new types of aircraft, is most gratifying. The Vulcan is giving us splendid utilization; indeed, it is far better than we experienced with any other type of aircraft, large or small. The Vulcan comes from a good stable and is liked by the servicing crews as well as the flying crews."

We are proud of our stable—from it have come: *the Avro '504'—the first long-range bomber of World War 1; the faithful Anson; the immortal Lancaster, used by the Dam Busters in World War 2; and now the Vulcan.*

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FIRST AERONAUTICAL WEEKLY IN THE WORLD FOUNDED 1909

FLIGHT
and
AIRCRAFT ENGINEER

No 2548 Vol 72 FRIDAY 22 NOVEMBER 1957

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821 The Sopwith Tabloid, Schneider and Baby—Part 3

Dilemmas are in Fashion

LAST week we reviewed proposals contained in Lord Weeks' Air League address. We entitled the review "The Industry's Dilemma". This week we print select passages from a paper by Dr.-Ing. Lachmann, director, scientific research, Handley Page, Ltd., which he calls "The Designer's Dilemma"; and we report also an interview with Hawker Siddeley chiefs which might have been aptly titled "A Manufacturer's Dilemma." So if we add our own dilemma we shall find ourselves in good company.

Clearly, the path out of the maze must begin with the turning that the British aircraft industry is taking sheerly by instinct. Already firms are in process of reorientating and adapting themselves to a new outlook of rationalism. The lengths to which the process of reorientation has already been carried beyond the aeronautical field was shown last week when the Hawker Siddeley chiefs reported that, whereas two years ago aviation accounted for 80 per cent of their group's activities, the figure today was only 30 per cent. But we must stick to our aeronautical last; and we note that Dr. Lachmann states categorically that the Government will in future demand co-operation of two or more firms in tendering for a contract. He foresees that the pooling of technical resources, design capacity and production facilities will speed delivery; and in this connection he pays *Flight* the compliment of quoting a question recently posed in this column, when he asks (concerning the time cycle of the modern bomber), "Has there ever been in history such a lengthy period for forging and tempering a new weapon?"

But that question is not merely rhetorical: it has little significance whatever beyond the academic, for not one supersonic bomber will now be succeeding the V-class. As Dr. Lachmann puts it, the "comfortable period" is ending—the period when military aviation could continue as a pacemaker for civil aviation, with the supersonic airliner following in the wake of the supersonic bomber, and with the commercial application generally subsidized by military development.

The designer's major dilemma, as Dr. Lachmann sees it, is how to adjust his creative ability within a rapidly changing universe wherein the demand for conventional military aviation is contracting, but which "indicates expansion in civil aviation."

This fashionable word "dilemma" is defined as "a choice between two alternatives, both equally unfavourable"; but Dr. Lachmann chooses to apply the term in a wider sense—to a position leaving a choice between two or more solutions without implying that all are necessarily unwelcome or unsatisfactory. We ourselves have always suspected a dilemma of being a chimerical beast that lurks in dictionaries, and on being driven into the open turns out to be nothing more than our old friend the challenge. And no self-respecting designing or planning office should ever be without one of these improving creatures.

The Naval Pattern

Another recent lecturer whose remarks invite comment is Rear Admiral D. R. F. Cambell, Flag Officer Flying Training. In a lecture at Brough (where the N.A.39 is coming along nicely under its British and American sponsorship) he puts forward the view that manned aircraft will remain in the Navy, but that development will be diverted from the aircraft itself to its equipment. For strike and air defence he visualizes the development of a long-endurance aircraft of moderate speed and ceiling, launching high-performance missiles. Guided weapons would be a most effective substitute for the close-range gun-defence system. But Admiral Cambell doubts whether it will be practical or economical to develop a long-range weapon to supersede the fighter unless some other customer (the R.A.F. or U.S. Navy?) can share the burden of development.

We are left with the reflection that the aircraft suggested by Admiral Cambell might be the N.A.39 itself—and that the missile might be the ultimate development of the SR.177 mixed-unit fighter, already earmarked for the Navy.

THE DUKE OF EDINBURGH is presented (left) with a model Whirlwind by Westland chairman Mr. Eric Mensforth; on the right he is seen, at Filton, inspecting a Britannia interior in company with Bristol chiefs Mr. Peter Masefield and (at rear) Sir Matthew Slattery.

FROM ALL QUARTERS

The Duke at Yeovil and Bristol

DURING his visit to the Westland works at Yeovil last Friday the Duke of Edinburgh flew the Widgeon. With Lt. W. H. Sear (chief test pilot) in the co-pilot's seat he was airborne for about ten minutes, during which time he made two take-offs and landings. Afterwards he expressed his appreciation of the Widgeon's handling characteristics and, in particular, the feel of the spring-loaded controls.

His Royal Highness, who had been received on arrival by Mr. Eric Mensforth (chairman), was conducted by Mr. Mensforth and Mr. E. C. Wheeldon (managing director) on a two-hour tour of the works. In the experimental shop he spent some 15 minutes in the mock-up of the 15-ton Westminster, by which—in the subsequent words of an onlooker—he seemed "quite fascinated."

Before leaving to go on to Bristol he was presented with one of the neckties reserved for qualified Service helicopter pilots—silver Whirlwinds and thin red lines on a blue background (he has had considerable flying experience in the Naval Whirlwinds and Dragonflies which he habitually uses as personal transport). He also accepted a silver model of a Whirlwind.

In the afternoon the Duke spent two hours at Bristol University, where, in the physics department, he talked with professors and lecturers on the International Geophysical Year work in progress there. He then went on to the Bristol Aeroplane Company's works at Filton, the main object of his visit being to see the Britannia production line. With Dr. S. G. Hooker (director and chief engineer of Bristol Aero-Engines), he conversed on the subject of the earlier engine-icing troubles, and later he saw an example of the Raven rocket motor as used in the Skylark high-altitude research rocket which, in Australia two days before, had reached a height of 83 miles (see page 792).

In accordance with a desire expressed by the Duke to fly in a Britannia, arrangements had been made for him to return to London in one of the long-range aircraft for B.O.A.C., but deteriorating weather at London Airport made this plan impracticable. His Royal Highness ultimately left in a D.H. Heron of the Queen's Flight, with Southampton as his destination.

Another Big Hunter Order

LAST week the Swiss Government announced that it was seeking parliamentary approval for the purchase of 100 Hawker Hunter 6s (Rolls-Royce Avon 200 series) at a cost of 312m francs (about £26m). The decision follows over a year of deliberation, in the course of which various Continental, Commonwealth and American fighters have been considered.

A Berne report says that the proposal will be considered in the Swiss Parliament early next month. If approval is given and the order placed, deliveries are expected during 1958-59. The Hunters would replace the Vampires and Venoms at present in service with the Swiss Air Force. The same report mentions the possibility of a further 100 aircraft being ordered in the near future, but adds that the government has not yet decided on the type.

Hunters are already in service with, in addition to the R.A.F., the Belgian, Dutch, Danish, Swedish and Peruvian air forces, and 100 are on order for India.

Unrefuelled Jet Distance Record

ON November 12 a U.S.A.F. KC-135 Stratotanker with a crew of 19 flew a record 6,350 miles from Westover, Mass., to Buenos Aires without flight-refuelling, in 13 hr 2 min. It returned to Washington, 5,204 miles along a more direct route, in 11 hr 5 min 0.8 sec on the following day, making an average speed of 469.5 m.p.h. against headwinds. In command of the machine, and at the controls for much of the time, was Gen. Curtis Lemay, erstwhile commander of Strategic Air Command, and now Vice-Chief of Staff, U.S.A.F. He is a qualified captain of many S.A.C. types and was awarded the Distinguished Flying Cross immediately after landing at Washington.

BIG WHITE CHIEF: Gen. Curtis Lemay, smoking cigar, supervises the flight of the record-breaking KC-135 (see above) to South America. He is a qualified and experienced captain of many of the Strategic Air Command types.

British Civil Jets

IN the House of Commons on November 18 Mr. W. J. Taylor, Parliamentary Secretary to the Ministry of Supply, confirmed that the Hawker Siddeley Group, with others, had made proposals for the private-venture development of a medium-range turbojet aircraft to meet a B.E.A. requirement (see "Sir Frank and Sir Roy Hold Court," page 792). Mr. Taylor added that a group of companies, in association with and under the direction of the Royal Aircraft Establishment, Farnborough, were making a research study of possible supersonic civil air transport machines. Much preliminary theoretical work had been done, the main experimental work had been planned, and certain research models were now being designed and manufactured.

Eland Convair for Certification

LAST Friday, November 15, Napier's Eland-powered Convair left Prestwick for Ottawa by way of Keflavik and Goose Bay. It was flown by Mike Randrup with T. Burke as second pilot and a B.O.A.C. navigator, S. A. Sharpe, among the total crew of nine. The aircraft arrived in Ottawa on Sunday.

The return to America, three years after Napier purchased this Convair 340 for re-engining with turboprops, marks the beginning of the final stage of the conversion programme. After giving demonstrations at Ottawa (the firm are reluctant to say to whom, but it may be significant that the Allison 501-powered Convair 340 was recently demonstrated there to the R.C.A.F.), the Eland Convair will be flown to Santa Monica, California, for C.A.A. certification trials. While it is there it will be looked after by PacAero, Napier's agents who are responsible for the conversion of REAL's Convairs and are installing Elands into the Convair 440 which Napier acquired about four months ago. Both aircraft will be made available for crew training and route familiarization to airlines adopting Eland-converted Convairs.

For its Atlantic flight, Napier's demonstration aircraft has been granted a Special Category A.R.B. certificate. A 150 hr type-test—

***COMMERCIAL TRAVELLER:** The de Havilland Comet 3 prototype flew to Zurich on November 13 to be sampled by Swissair. Dr. Rudolf V. Heberlein, the airline's chairman, made flights over the Alps with his co-directors and with senior executives of the airline. Swissair, who are expected soon to decide on their medium transport re-equipment programme, are studying the new 4C, described in "Flight" last week.*

a necessary preliminary for C.A.A. certification—at the full NEI.6 rating of 3,500 e.h.p. has not yet been run but, now that preparation of the demonstrator is complete, say Napier, the observed test is "imminent."

TV Discussion on the Industry

IN the B.B.C. television programme *Panorama* last Monday night Sir George Edwards, Mr. E. C. Bowyer, Rear Admiral Sir Matthew Slattery and Dr. G. V. Lachmann were asked for their views on the British aircraft industry. On the whole, considering that they were expected to give balanced answers to Woodrow Wyatt's weighted questions in the space of seven minutes, they did quite well. It seemed a pity, however, that a potentially useful piece of television journalism should have been in such a rush to beat the studio clock.

Sir George Edwards felt that if the industry concentrated its resources to back up its brains it could "see its competitors off." Mr. Bowyer thought "the present set-up is pretty efficient"; it was exporting at the rate of £100 million a year, and he did not agree that a great deal of money had been wasted on it. He hoped that any amalgamations would happen naturally. Sir Matthew Slattery did not deny that the Britannia was late, but pointed out that it was the final result that mattered. The Britannia 102's reliability was such that it was getting in more hours a day [7¾ hr per aircraft; B.O.A.C.'s *overall* figure is 6.91 hr/aircraft/day—Ed.] than aircraft that had been in service for some time. He did not think that the 707 and DC-8 "would knock us out altogether": air transport would increase only by cheap fares, which were what the turboprop would bring. Dr. Lachmann made a plea for more Government support of basic research, "the lifeblood of the industry"; and Sir George had the final word by saying that it would be a big help to the industry if it could sometimes have a bit of encouragement instead of ill-informed comment.

Aviation M.P.'s New Chairmanship

WELL known for his knowledgable comments in the course of aviation debates in the House of Commons, A. Cdre. Sir Arthur Vere Harvey, C.B.E., M.P., who is deputy chairman of Handley Page, Ltd., has accepted an invitation to become chairman of the Boards of Aero Research, Ltd., Duxford, and of Ciba, Ltd., Horsham. In announcing the appointment, Aero Research state that he succeeds Sir Raymond Needham, Q.C., who has been chairman since 1947 and remains a director of both companies.

A. Cdre. Sir Arthur Harvey.

Sir Arthur, who is 51 years of age, first served in the R.A.F. from 1925 to 1930, qualifying as a flying instructor, and was the founder of No. 615 (County of Surrey) Squadron, R.Aux.A.F. During the succeeding years he had civil aviation interests in the Far East, and also served as adviser to the Southern Chinese Air Forces. In 1939-40, during his second period of R.A.F. service (1939-45), he commanded No. 615 Sqn. in France, and was twice Mentioned in Despatches. Since 1945 he has been M.P. for the Macclesfield Division of Cheshire, and chairman of the Conservative Party Civil Aviation Sub-Committee. His directorships include those of Mullard, Ltd., and Philips Electrical, Ltd.

Sputnik II Details

ADDITIONAL information was given in Moscow last week concerning the second artificial Earth satellite. An editorial article in *Pravda* of November 13 described the structure of the satellite (pictures. p. 792), and at a Press conference two days later the first official announcement was made that the dog Laika had died from a deficiency of oxygen.

The *Pravda* article stated that, on the basis of data from the tracking of the first sputnik, this satellite's life would be about three months from the date of launching (October 4). The life of its carrier rocket would be shorter than this, and the second sputnik would continue in orbit for "an appreciably longer time than Sputnik I." Also included in the article were the following extracts:

"Soviet Sputnik II, as distinct from Sputnik I, is the last stage of a rocket, housing all the scientific and measuring equipment. This method of housing the equipment appreciably simplified the task of ascertaining the sputnik's bearings by means of optical observation. . .

"Both the chamber for the test animal and the spherical container were made of aluminium alloys. They had a polished surface, specially treated so as to impart the required coefficients of emission and absorption of solar radiance. The heat-regulating arrangement inside the spherical container and the animal's chamber maintained a fixed temperature, deflecting the heat into the hull by forced gas circulation. . .

"Though the use of high-altitude rockets has also yielded valuable results, only the sputniks enable us to carry out systematic measurements over the long periods of time necessary to study the variations in the intensity of short-wave ultra-violet radiation.

"Three special photo-electronic multipliers, set at an angle of 120 degrees to each other, serve as receptors of radiation. Each photo-multiplier is consecutively covered with several filters of thin metallic and organic film and also of special optical materials, making it possible to single out the different bands in the X-ray region of the solar spectrum, and the hydrogen line in the extreme ultra-violet region. The electric signals given out by the photo-multiplier trained on the sun were amplified by radio devices and telemetered to stations on the ground.

"Owing to the continual change in the sputnik's bearings in relation to the Sun and also owing to the fact that part of its orbit was not lit by the Sun for a certain period of time, the electric circuits in the apparatus were switched on, in order to feed the batteries, only when the Sun came within range of vision of any of the three light receptors. This was done by means of photo-resistors lit by the Sun at the same time as the photo-multipliers, and by an automatically functioning device. . .

"The particles comprising cosmic radiation are recorded aboard the sputnik by means of counters of charged particles. When the counter traps an electrically charged particle, a spark arises, sending an impulse to a radio arrangement of semi-conductor triodes, the purpose of which is to count the number of cosmic ray particles and send out a signal when a definite number of particles has been counted. . .

"The sputnik had two identical devices for recording charged particles. The axes of the counters in the two devices were reciprocally perpendicular.

"Preliminary systematization of data provided by the sputnik on cosmic radiation has shown that both devices functioned normally. The dependance of the number of cosmic-ray particles on the geomagnetic latitude was clearly discernible. . ."

Referring to the study of biological phenomena in connection with the test dog Laika, the article stated, "Already at the present time we can say that the test animal stood up well to the protracted effects of acceleration when the sputnik was being aligned on orbit and to the subsequent state of zero gravity which continued for several days . . ." Confirmation that the dog had died came at a Moscow Press conference on November 15, when Prof. Alexei Pokrovski said, "The dog Laika is dead. The work of the oxygen regeneration plant came to an end when the experiment finished."

By Tuesday last the two satellites had completed 700 and 250 orbits respectively. In Washington, a possible delay in launching the first fully instrumented U.S. satellite was reported; the first test satellite launch remained scheduled for December.

Croydon Gets a "No"

QUESTION and answer about the future of Croydon airport in the House of Commons on November 13 brought a reaffirmation from Mr. Airey Neave, Joint Parliamentary Secretary to the M.T.C.A., of the Minister's decision to close the airport. An informal meeting with representatives of tenant firms and aero clubs has been arranged for today at Biggin Hill, the alternative airfield which the Minister has proposed.

The Minister's refusal to reconsider the continuation of Croydon notwithstanding, there is likely to be considerable resistance to any move to Biggin unless adequate assurance can be given that access and facilities will be improved and the air traffic control problem will be considerably eased.

Hawker P.1121: Late Report

COMMENTING on the report (page 792) that work had been stopped on the P.1121, Hawker Aircraft state as we go to press, "The expression 'cocooned' was merely a figure of speech. Work has not been stopped, although it is going on at a very much reduced rate." They hoped that orders would come; and the work would then be "at full bore."

FROM ALL QUARTERS . . .

Sir Frank and Sir Roy Hold Court

ON Wednesday of last week Sir Frank Spriggs, managing director of the Hawker Siddeley Group, answered questions in London about the aviation interests of his Group. With Sir Roy Dobson, chairman of A. V. Roe Canada, he had just returned from a visit to the U.S.A. and to Canada (where they had completed the 76 per cent purchase of the Dominion Steel and Coal Corporation).

Sir Frank explained how the Group was steadily broadening its non-aviation industrial interests: whereas two years ago aviation accounted for 85 per cent of the activity, it was now only 30 per cent. "I think that change is the measure of the success of our expansion and diversification programme." But he remarked that if the aviation interest were "allowed to melt away" it would be "the biggest crime the government has ever committed to this country."

The big surprise was Sir Frank's reply to a question about Hawker's private venture strike aircraft, the P.1121. It had, he said, been "put in mothballs until someone sends a telegram telling us to build a lot of them." It had reached a development stage with which they were "more than satisfied." Production jigs were built, but there was as yet no customer, although there was NATO interest in the project. The 1121 was to be powered by a D.H. Gyron. The Hawker order-book was, Sir Frank said, filled for four years, and Gloster's for three and a half.

The Avro 740 project competing for the B.E.A. jet transport order is still in the running: Sir Roy Dobson said that the decision had been "coming in a fortnight for months now." Avro's offer to finance the development of the project still stood: in other words, the £17m to £20m required would be recouped by export orders. Sir Frank mentioned interest in an executive aircraft, saying that it was not intended to buy a certain project in which they had been interested at one time. The interest in the licence-construction of a helicopter was being contemplated; and the supersonic transport project was by no means dead. The Government had had the design study submitted to them some time ago. Interest in the AW.650 had, he said, been "beyond expectations," but no options had yet been placed.

Of the Arrow, Sir Roy remarked that it was "half an era" ahead of anything else in the western world. The Orenda Iroquois turbojet was being contemplated for several U.S. aircraft, through Curtiss-Wright.

Skylark Progress

A SKYLARK high-altitude research rocket fired on November 13 from the Woomera range, South Australia, achieved a height of 83 miles carrying equipment for four types of high-altitude investigation. This launching was the fourth of six preliminary firings scheduled to precede the joint programme of upper-atmosphere research, by the Royal Society and the Royal Aircraft Establishment, for the International Geophysical Year.

The Ministry of Supply stated that the first three firings had shown the performance of the rocket vehicle and its Raven solid-propellant motor to be "very satisfactory," and that attention had now been turned to trials of the equipment and instrumentation carried by the rocket, and of special ground equipment. The equipment carried by the fourth Skylark was under test during the flight. The four special installations were:—

(1) To measure atmospheric temperatures and high-altitude wind velocities: a series of 18 explosive grenades, ejected from the rocket at intervals above 100,000ft. Ground equipment included microphones to record the arrival of the sound-waves, ballistic cameras to record the position of the explosive flashes, and a detector to record the instant of each flash. This experiment was by University College, London.

(2) To measure winds at altitudes up to 50 miles: fourteen cartridges of "window" foil, released explosively in two clouds at heights above 100,000ft. These clouds were tracked by ground radar, and the experiment was devised by Imperial College, London.

(3) To measure ionospheric electron densities: a section of the rocket nose, insulated to form a fixed-capacity condenser and included in a 5 Mc/s oscillator circuit able to detect the presence of electrons in the ionosphere. The results in this experiment, which was devised by the University of Birmingham, were telemetered to the ground.

(4) To determine the undisturbed ambient pressure at various altitudes: three Pirani pressure gauges carried in the rocket cone, one measuring ram pressures at the tip, and the other two measuring cone wall pressures. (An R.A.E. investigation.)

Other equipment carried included timing gear and switches, telemetry transmitter, power supplies, Doppler transponder and microwave beacon, the last two units giving velocity and position for tracking purposes.

Nuclear Talk at NATO

DURING last week's parliamentary conference of the fifteen NATO countries many proposals were advanced—no doubt under the impetus provided by Russia's recent satellite achievements—in an effort to accelerate the scientific ability of the Western nations.

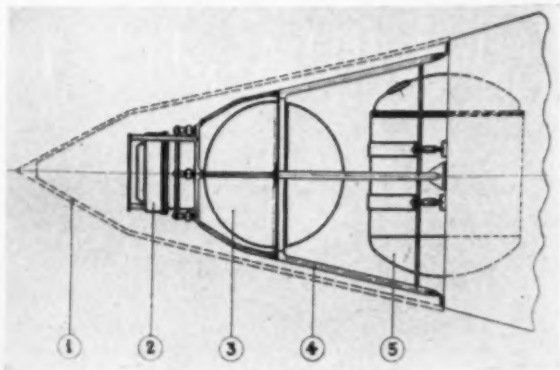
Senator Jackson of the U.S.A. suggested that the NATO countries should establish a missile training centre, and that at least 500 doctorates should be awarded annually "in the sphere of maximum importance for the defence and economic well-being of the Atlantic community." General Thomas S. Power made it clear that the impressive standard established by Strategic Air Command has in no way diminished since he took over from General Le May earlier this year; a 15-min alert was ordered throughout the Command on October 1 and this state of readiness "will soon be operative throughout one-third" of S.A.C.

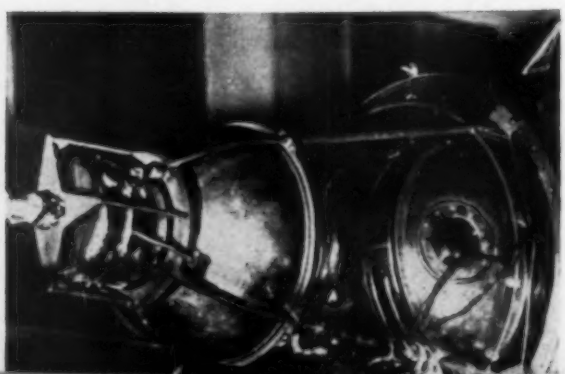
Senator Kefauver, chairman of the NATO political committee, is quoted as saying "we are very interested in Firestreak; we think it one of the best weapons of its kind available."

D.H. Old Boys Dine

IN London on November 9, some 60 old boys of the de Havilland Aeronautical Technical School and their ladies gathered for the annual dinner at Simpson's-in-the-Strand. It is the custom on these occasions for the guest speaker to have, or to have had, associations with de Havilland during his career, and the guest of honour last Saturday, A. Cdre. Sir Vernon Brown (best known as a former Chief Inspector of Accidents at the Air Ministry and later the M.C.A.) reminisced about the earliest de Havilland aircraft, many of which he had flown.

There are now 567 members of the Old Boys' Association, 163 of them with de Havilland companies, and 87 in the North American branch.





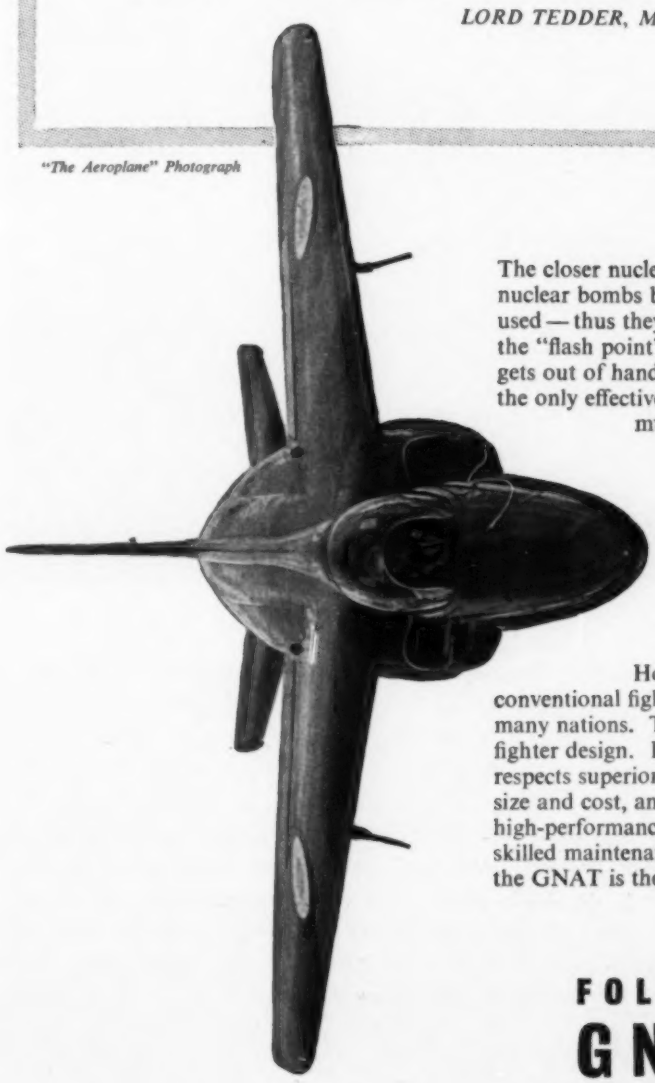
IN THE DOGHOUSE: First photographs of the second Russian satellite were released last week. Below, the dog Laika in her compartment; right, photograph and diagram of the interior layout. 1, nose-cap; 2, apparatus for registering ultra-violet rays and X-rays; 3, spherical container for instruments and radio transmitters; 4, protective framework; 5, hermetically sealed compartment for dog. (See page 791.)

"TAKE MY WORD FOR IT—

there are going to be aeroplanes and military aeroplanes, too, as far ahead as we can see. The idea that we are all going to sit in dug-outs and press buttons is just fantasy."

LORD TEDDER, MARSHAL OF THE ROYAL AIR FORCE

2 June 1957



"The Aeroplane" Photograph

The closer nuclear parity approaches, and the more devastating nuclear bombs become, the less likely it is that these bombs will be used — thus they lose all value as deterrents to local conflict. Yet the "flash point" of nuclear war may well be the local one which gets out of hand. Strong and flexible conventional force remains the only effective deterrent to local conflict, and the air component must be the first consideration.

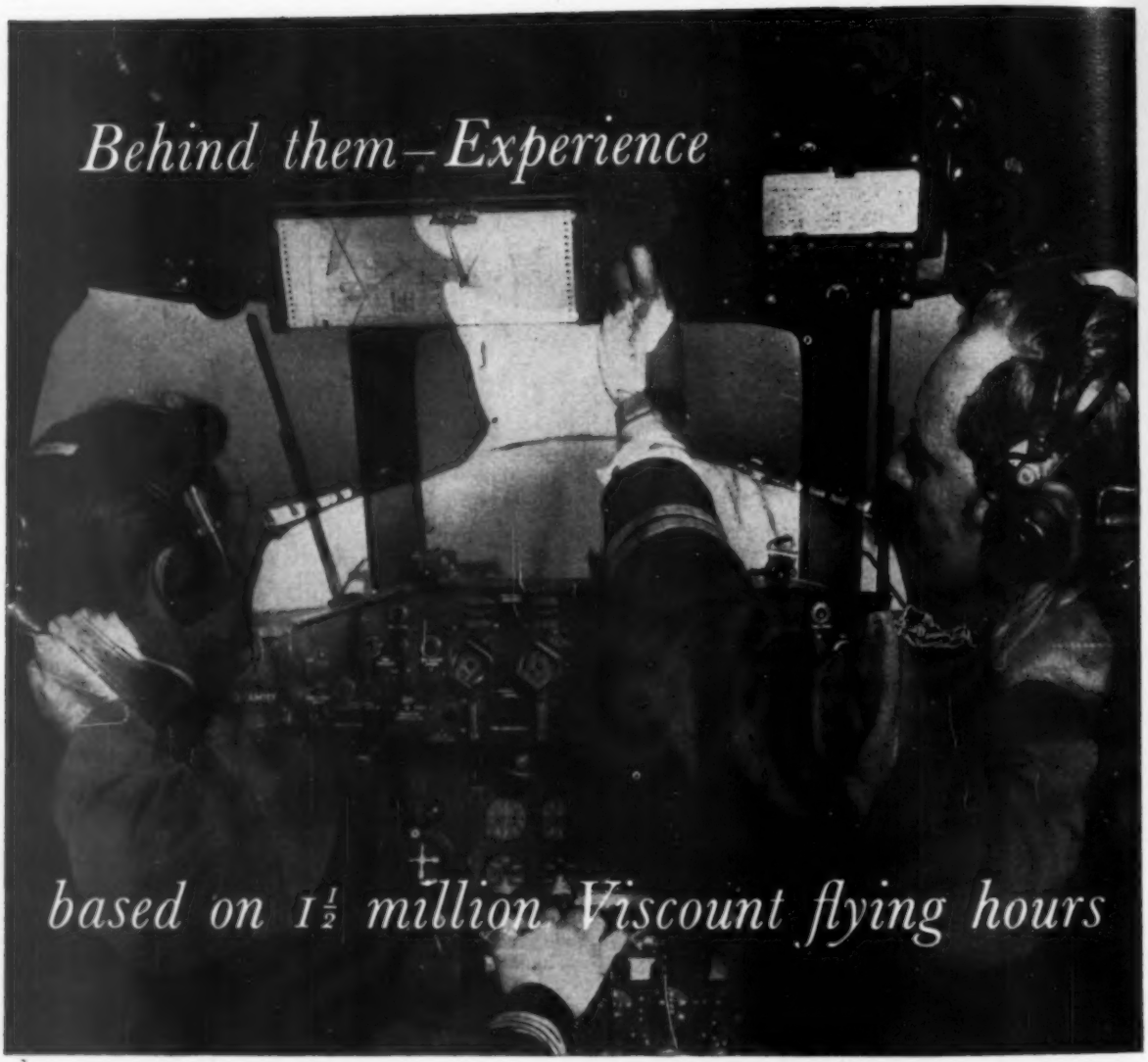
However, the size, complexity and cost of the conventional fighter imposes a crushing burden on the economy of many nations. The Folland GNAT has reversed this trend in fighter design. It has proved equal in performance, and in many respects superior to the conventional fighter, yet it is only half the size and cost, and a third of the weight. It can operate wherever a high-performance machine can go and it makes little demand on skilled maintenance. As a modern air superiority or tactical fighter the GNAT is the right aircraft, for the right job, at the right time.

FOLLAND

GNAT

LIGHT JET FIGHTER

FOLLAND AIRCRAFT LIMITED, HAMBLE, SOUTHAMPTON, ENGLAND



TAA Breaks Records with Viscounts

Mr. John P. Ryland, General Manager of Trans-Australia Airlines, recently commented on TAA results for the year ending June 1957. He pointed out that the year had been the second in succession during which TAA has carried more than three quarters of a million passengers, a figure never attained by any other Australian domestic airline. Introduction of more large, speedy Viscount aircraft had enabled TAA to carry the record number of passengers (793,946) on 26,493 separate flights, more than 2,000 fewer than in the previous year.

Pilots have many reasons for preferring the Viscount with its proved and reliable non-powered flying controls.

Viscount experience in service with over 20 airlines is being built into the simple functional cockpit and cabin layout of the new Viscount 810-840—ensuring for both pilots and passengers that comfort and freedom from strain which is now associated with Viscount travel. In this new Viscount the proved dependability of the airframe and the Rolls-Royce propeller-turbine, after ten years of development and 1½ million flying hours, means peace of mind for both crew and passengers. Quiet, smooth flight reduces fatigue and improves efficiency, while the rapid turnround due to ease of maintenance means less worry over schedules.

There is no substitute for experience

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED WEYBRIDGE SURREY

ATS TGA483

One month ahead of schedule, the first Lockheed Electra, N1881, emerges from the Burbank factory on November 11 (see news item in Col. 2). The paint-scheme is blue and white. Target-date for the maiden flight, which looks as though it may be beaten, is January 31. Lockheed, incidentally, are promoting the Electra as a "prop-jet" rather than as a turboprop.

CIVIL AVIATION

B.E.A. FREIGHTER ACCIDENT

A VISCOUNT 802 of B.E.A., on the regular night-freight service from London to Copenhagen and Hamburg, made a forced landing near Ballerup, six miles west of Copenhagen, in the early morning of November 17. The crew of two was unhurt. The aircraft, G-AOHP, was extensively damaged, and is understood to be a write-off. The five tons of freight and mail on board were salvaged.

The pilot, Capt. R. I. McLellan, is reported to have said that three engines failed five minutes before he was due to land at Copenhagen, and that he had to make a forced landing in the dark.

A B.E.A. team flew to Copenhagen to make an on-the-spot investigation a few hours after the accident.

FLYING-BOAT TRAGEDY

WITH much regret *Flight* records the accident to a Short Solent of Aquila Airways on the night of Friday last, November 15, in the Isle of Wight. Of the 58 people on board, 45 (including the flight and cabin crew of eight) were killed, and 13 injured, six of them seriously.

The boat, a Solent 3, G-AKNU, had taken off from Southampton Water at about 2240 hr on the once-weekly holiday service to Madeira and Las Palmas *via* Lisbon. About 20 minutes after take-off the pilot, Capt. F. Eltis, called the control launch on Southampton Water to say that No. 4 engine had failed and that he was returning. Ten minutes later the aircraft struck sloping ground near Shalcombe Hill, Yarmouth, on the north-west tip of the Isle of Wight, caught fire and, with the exception of a portion of the tail, was destroyed. Visibility at the time of the accident was reported by eye-witnesses as "misty."

The Minister of Transport and Civil Aviation ordered a public inquiry into the accident, which was the first involving injury to an Aquila passenger in eight years of flying-boat operations.

The Solent was one of four owned by Aquila, which is a member of the British Aviation Services group.

THE ELECTRA ROLLS OUT

AS the photograph reproduced above testifies, the first Lockheed Electra has emerged from the Burbank factory. The actual roll-out date was November 11, which Lockheed say was one month ahead of schedule. The U.S. firm might with equity have claimed that it was six weeks ahead of schedule, since the roll-out target-date—fixed more than a year ago—was December 1957. However, British manufacturers who might wish that their target-dates were less elusive than those of the Americans (*vide* 707 and JetStar) find comfort in the thought that even Lockheed's target-dates are perishable; two-and-a-half years ago, *first-flight* target-date for the Electra was October 1957. [*continued overleaf*

From Sixth-Former to First Officer

IT is all very well to talk grandly about Britain's future as a mercantile air power, and to provision for fleets of splendid airliners, when in a few years' time there may not be enough pilots to fly them. The old-timers—the veteran four-ringers who have grown up with aviation—are already getting their feet under office desks, or digging their gardens. The wartime aircrews, those who form the bulk of the profession today, are turning forty; and though they have a good few years of service ahead, the source whence they came, the flying Services, can no longer be counted on for future adequate supplies. Meanwhile, the demand for commercial pilots increases in proportion with air transport.

Obviously, the future of the British airline piloting profession will not be assured by assuming that youth will run away to the air as it did to the sea. It costs a great deal to qualify for a Commercial Pilot's Licence; and neither the airline nor the pupil can be expected to foot a large bill. So far, despite strong campaigning by the Air League, the Government have not agreed to support a national pilot-training scheme (as the governments of other countries, notably Holland and France, have done).

But yesterday, United Dominions Trust, the London banking house, was associated with a newly formed company, to be known as General Air Training, Ltd., whose purpose is to "make it possible for airline operators to select and engage suitably educated schoolboys for training to first-officer standard, in such a way that neither operator nor prospective pilot will be involved in heavy cost."

The plan (which will no doubt come to be known as the G.A.T. scheme) is for the operator to contribute £1,600 on completion of a pilot's 12-month course with Air Service Training, Ltd., and for the pilot to pay the balance in 36 monthly instalments of between £34 and £35. As a young first officer of 19 or 20, presumably without heavy financial responsibilities, this will be about a third of his salary.

The people behind the scheme—the directors of General Air Training—are already engaged in various commercial aviation activities. They are: Mr. I. A. F. Donnelly (managing director); Mr. L. R. White; Mr. M. T. Harraway; Mr. Colin Cooper.

The response of the airlines to this new scheme—which caters also for helicopter conversion training—must now be awaited. This may take time, since the shortage of pilots is not yet so crucial as to make the expenditure of £1,600 for a new first officer readily accepted. The question is, when the shortage comes, will the airlines find a cheaper way of meeting it?

There should be no lack of school-leaving-age boys who will want to know more about this opportunity of taking up airline-piloting as their professional career. All those who in the past have written to *Flight*, for example, wanting to know how to become an airline pilot, at last have an *entrepreneur*.*

The scheme, if it develops, presages an expansion of Air Service Training, Ltd., who may come to be regarded by the airline industry as H.M.S. *Conway* is by the Merchant Navy, or as Cranwell is by the R.A.F. One thing is certain—an airline industry without apprentice pilots is an industry without a future.

* *Enquiries, from both operators and applicants, should be addressed to: General Air Training, Ltd., 1, Gt. Cumberland Place, London, W.1.*

CIVIL AVIATION . . .

Flight noted in the "Airliners" issue of November 1 that the design maximum payload of the Electra was to be increased to 26,500 lb. New Lockheed figures now confirm this: it appears that by adding 50 lb to the structure, zero fuel weight has been increased by more than 5,000 lb to 86,000 lb. Gross weight stays at 113,000 lb.

Obviously, the Electra's capacity would not allow 26,500 lb payload to be accommodated in the form of passengers; and a typical payload for the 85-seat version remains at 21,500 lb. But it emphasizes the cargo-carrying capability of the Electra.

The Electra's 405 m.p.h. cruising speed has, incidentally, now been guaranteed by Lockheed to within plus or minus five m.p.h.

C.P.A.L. APPLY FOR DOMESTIC ROUTES

FOR some years now Canadian Pacific Airlines have made no secret of their wish to compete with their nationalized rival T.C.A. on Canada's main domestic routes. C.P.A.L. have decided to campaign publicly for such routes, and they have formally applied to the Canadian government's Air Transport Board for air traffic rights at Vancouver, Calgary, Edmonton, Saskatoon, Regina, Winnipeg, Toronto, Ottawa and Montreal. The proposed route pattern would, they say, "directly duplicate only 10 per cent of Trans-Canada Air Lines inter-city services." C.P.A.L. add that they will be able to start services as soon as approval is granted, and that they will make available to domestic service a fleet of 15 DC-6Bs.

The chairman of C.P.A.L., Mr. W. A. Mather, says he is convinced that "the time has come to satisfy the public demand" for competitive domestic air services in Canada. He argues that T.C.A., after a 20-year monopoly, should now be "strong enough" to stand up to competition in a prospering economy.

Possibly T.C.A.'s recent decision to decrease domestic tourist fares by ten per cent, as recorded on another page, may have been timed to show the public that their national airline is serving its interests in an efficient manner. T.C.A. will certainly contest any participation by C.P.A.L. in Canada's trunk route transport system. T.C.A.'s future programme—involving 20 Vanguards and a total of 51 Viscounts—has presumably been worked out on the assumption that their monopoly would continue. The figure of ten per cent mentioned by C.P.A.L. does not seem to reflect the amount of business which might be diverted from T.C.A., since the cities applied for are the heaviest traffic-generators in Canada, and 15 DC-6Bs represent a capacity amounting to about 45 per cent of T.C.A.'s total output in 1956, international as well as domestic.

POLISH TRANSPORT PROJECT

FOLLOWING publication of our "Commercial Aircraft" special issue (November 1) further details have been received of the MD-12 Polish transport project. There have been two versions of this design, and it is the four-engined MD-12 for which P.L.L. Lot, the Polish airline, have placed an order (for an unspecified number). The twin-engined machine was shelved at the drawing-board stage and P.L.L. issued a new specification calling for a larger machine with four 320 h.p. (340 h.p. for take-off) WN-3 radial engines, "thus increasing payload capacity—20 passengers and 440 lb of baggage—as well as the margin of safety over the twin-engined design."

The new machine, it is reported, is due to fly in the spring of 1958. According to the published particulars it will probably look something like the Handley Page Leonides Herald scaled down, but with a low wing. The MD-12 is expected to fulfil a demand on Polish internal routes and also to meet a requirement for short-haul transport between Poland and the capitals of neighbouring states. With a full payload of 3,750 lb it is expected to cruise at more than 165 m.p.h. at 67 per cent power at 8,000ft, to have a practical range of approximately 280 miles and to take off from grass runways in about 820 yd to clear 50ft." Other reports quote the cruising speed as about 180 m.p.h., the range as about 400 miles and full payload as 4,180 lb.

The MD-12 will not have the T-type tail assembly which was to have been employed on the earlier version, but reverts to a more conventional layout. The aircraft was designed by the IL (Aeronautical Institute) in Warsaw with the close co-operation of the airline. The following data on the MD-12 have been published in the Polish aviation magazine *Skrzydlata Polska*:

Span, 69ft 10½in; length, 51ft 8in; height, 19ft; wing area 592 sq ft; weight, 16,280 lb. First flight is expected to take place next spring. A larger 50-60 passenger version of advanced design, with two 1,000 h.p. Narkiewicz turboprops, is under consideration.

A dramatic close-up of the second prototype Friendship, as seen recently by Fokker's photographer from the cockpit of the first machine. As already reported, the Friendship has received its American C. of A.

INCREASING RACEHORSE UTILIZATION

TODAY, November 22, the British independent airline Skyways were due to start what may well be the world's first scheduled service for animals. Racehorses will be carried, at a timetable frequency of one to seven services a week, between Stansted, Essex, and Beauvais, Paris, with an optional traffic stop at Blackbushe (near Ascot).

The idea is to allow racehorse owners to send their animals to Britain or France within a few hours of a race, and to have them back in the stable again next day. Skyways will use specially equipped Yorks, and will charge a maximum fare of £44 per animal.

Regular visitors to London now are Czech Il-14s, such as the one shown here. They work in pool with B.E.A.'s Viscounts on the new service to Prague, but it is possible they may be replaced next year by Tu-104As, the first of which has been delivered to C.S.A.

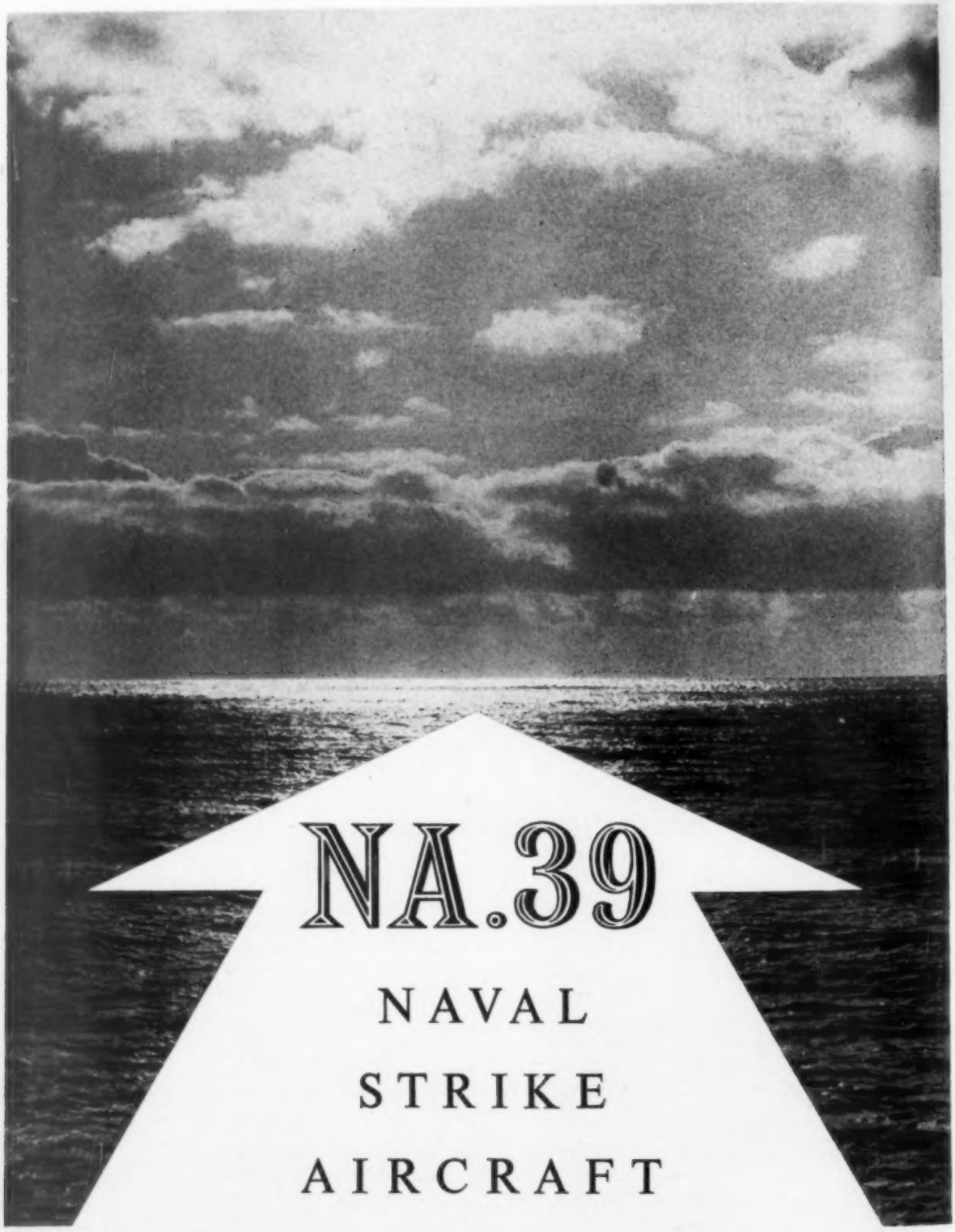
Completed in only 108 days!

Richard
COSTAIN
Limited

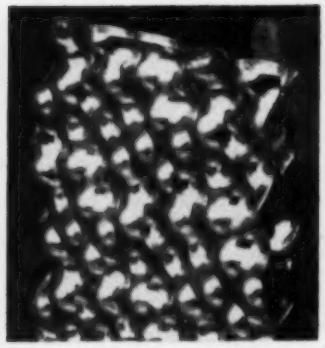
PLANNING • PRE-FABRICATION • THREE-PHASE CONSTRUCTION

Only 4½ months were available for completing this £250,000 contract. In beating this tight schedule by 7 weeks, a very high degree of planning was called for, and the main construction involved a flexible system of pre-fabrication on a major scale. The West London Air Terminal is, in fact, one of the world's largest pre-constructed buildings for public use. With the actual building operation divided into three meticulously dovetailed phases, this project is yet another example of the speed, efficiency and technical resourcefulness of the world-wide Costain organisation.

UNITED KINGDOM • MIDDLE EAST • RHODESIA
NIGERIA • CANADA • WEST INDIES



BLACKBURN AND GENERAL AIRCRAFT LIMITED BROUGH EAST YORKSHIRE
AB6/a



A model of the big flying-boat project announced last week by the London engineering firm of Saben, Hart and Partners is depicted here (with a Viscount 800 model for contrast). The smaller photograph on the right shows a sample of the Calotton light alloy sheet which is to be the basis of the new aircraft's construction. The design study is apparently quite serious, though no constructor has yet been associated with the project. Development cost is said to be about £20m. There are to be two versions, each powered by eight 25,000 s.h.p. turboprops (of unspecified make). Details appear at the foot of the next page.

CIVIL AVIATION . . .

DR. LACHMANN ON AIR TRANSPORT PROGRESS

ALTHOUGH the title of the paper which Dr. G. V. Lachmann, Handley Page's director of scientific research, read to the Royal United Service Institution last Wednesday was *The Designer's Dilemma,* it contained certain views of air transport interest. As might have been expected, Dr. Lachmann gave prominence to the case for laminar flow; but he touched also upon the other transport fields. Here is a summary of his remarks.

The air transport future, commented Dr. Lachmann, had already been decided. It was like a play with the actors cast, the première imminent, and the run assured for at least ten years. He recalled the "excellent forecast" given recently by Mr. A. E. Raymond (*Flight,* September 20), engineering vice-president of Douglas Having summarized Mr. Raymond's remarks, the speaker examined the future pattern himself.

On the trunk lines, the long-range jet would dominate the picture—"and, alas, the aircraft will be mostly American-built." The benefits which passengers would enjoy would follow from the technical progress implicit in the enormous engineering effort which had gone into the development of jet bombers. The advances in speed and comfort justified "an optimistic outlook towards the growth of passenger traffic in the coming decade."

Trunk lines also existed where demand was not only for long-range service. For stages of up to 2,000 miles, where traffic density was inadequate for economic operation of long-range jet transports and where airport and runway facilities were restricted, smaller jet transports would be required. Turboprops were indicated for still shorter stages.

In the cargo field, world air cargo had grown at a 25 per cent annual rate; and the speaker referred to Mr. Raymond's future predictions about air cargo. Raymond's suggestion that in 1967 world air cargo volume might be 11,000 million ton-miles "demands a radical view of our concept of air freight handling, and also of the aircraft which will be required to do the job." Ordinary airliners designed exclusively for passenger transport were "completely unsuitable."

Dealing again with long-range jet transportation, the speaker referred to Raymond's view that most of the air commerce world lay within the area of the globe enclosed by a circle of 6,400 st.m. radius with its centre based on Amsterdam or London. Within this area lay 90 per cent of the world's commerce. "In the foreseeable future it should," said Dr. Lachmann, "become possible to connect most of the capitals of the world in less than a single day's flying without necessitating supersonic cruising speeds."

There was, therefore, "a pressing need for more air miles per gallon." This could be achieved (1) by reducing specific fuel consumption; (2) by the use of higher energy fuels; or (3) by improving the lift/drag ratio.

The prospect of lowering consumption was limited, and the ideal engine for jet transport aircraft would be "by-pass engines of higher by-pass ratio than the Rolls-Royce Conway."

The use of high energy chemical fuels was at present prohibited by cost and by "a number of technical reasons."

For a number of years Handley-Page had devoted research to the third possibility—the improvement of lift/drag ratio. No further reduction in drag seemed possible by conventional means. Almost half the total drag was caused by skin friction due to boundary layer. By sucking a small amount of this layer through the surface of the aircraft it could be maintained in the laminar state.

The investment of part of the engine power in this way paid a dividend in the form of more air miles per gallon. The net result was the same as if the specific consumption of the engines of a

Progress at Gatwick is recorded in this picture, which shows the old racecourse station in the foreground. The new terminal building shows the A23 road going through and under the flyover. Target-date for opening is next April.

CIVIL AVIATION . . .

conventional aircraft had been reduced by 50 or 60 per cent, or if the heat content had been doubled. "Design studies which we have made indicated the possibility of achieving lift/drag ratios of up to 40."

S.T.O.L. aircraft such as the Twin Pioneer "could help open up the vast areas of the globe which are at present barely touched." VTOL aircraft such as the Fairey Rotodyne "offer the prospect of fast inter-city services, eliminating the necessity for aerodromes outside towns and cutting out frustrating surface delays."

Supersonic transport *prototypes* might appear before the end of the sixties, but it was doubtful whether they would be in operation by that time. Though we had the technical know-how, the shorter range and high operating costs associated with supersonics would be untenable to the airline world, "and we think such aircraft will depend upon developments in powerplants and fuels unlikely to be available until the seventies." Non-stop transatlantic range was about the maximum which could be contemplated, and even this came close to ultimate range. However, there could be no doubt that supersonic transports would enter the field of air traffic in about 1970 to 1975, "if only to offer a more rapid service to a special class of passenger, and not to the majority."

Big business for the airlines will be created by the Brussels 1958 World Exhibition. Already Sabena have painted the motif of the Exhibition on the noses of their aircraft, such as this Convair Metropolitan.

BREVITIES

TWO Twin Pioneers are now being operated by British International Airlines, the B.O.A.C. associate in Kuwait, on behalf of the Kuwait Oil Company. One of Scottish Aviation's demonstrators was this week due to visit Dusseldorf, Hamburg and Frankfurt.

* * *

East Germany is said to be planning to build the Tu-104 under licence at Dresden, where Il-14s are in production.

* * *

K.L.M. made a net profit of just over £1.9m in the first nine months of this year, a slight increase over the corresponding figure for last year.

* * *

Mr. Derek Lambert, head of Vickers' civil aviation development group, is expected to arrive in Sydney in a few days' time to discuss the Vanguard with Australian airlines.

* * *

A net profit of £45,480 was made by N.Z.N.A.C. last year. Revenue, which for the first time exceeded £3m, was 14 per cent up on the previous year.

* * *

T.W.A. announce three new non-stop L.1649A services between New York and Frankfurt, Zurich and Madrid. Non-stop services—from both east and west coasts of U.S.A.—are already operated to London, Paris and Rome.

* * *

A million-pound policy is being taken out in Australia on the life of Mr. R. M. Ansett, chairman and managing director of Ansett Transport Industries, which recently acquired A.N.A. The policy is payable to A.T.I.

* * *

An American source reports that Republic Aviation are testing airline reaction to a four-turboprop transport project, for which the name Rainbow has been revived. It is said to be similar to the Viscount.

A party of B.O.A.C. reservations staff has been visiting the U.S.A. as guests of American Airlines. Their nine-day stay, which ended on November 10, included visits to the company's bases and to B.O.A.C. units.

* * *

The de Havilland Aircraft Company's project to re-engine the Dove with turboprops is reported in *Aviation Daily*. Two 520 h.p. Lycomings instead of the 380 h.p. Gipsy Queen Mk 2s would increase the cruising speed from about 200 to 240 m.p.h.

* * *

The American C.A.A. is experimenting with special cameras, supplied by Gordon Enterprises of Hollywood, designed to make a record of radar screens. If successful, this may lead to the use of such cameras to record automatically all aircraft landings and take-offs.

* * *

During a visit to Cologne last week, Mr. Hall Hibbard, engineering vice-president of Lockheed, again referred to the possibility of a Lockheed supersonic transport. He said that the U.S.A. would be able to build a VTOL Mach 3 airliner by 1963 or 1964, and could have it in regular service before 1967.

* * *

The *I.A.T.A. Directory of Airline Films* provides complete descriptions of more than 100 tourist and travel films, and about 40 special feature films. Most of the films are 16 mm colour with sound. Copies are available to responsible agencies from the public relations office of I.A.T.A., Terminal Centre Building, 1060 University Street, Montreal 3, Canada.

* * *

Mr. Gordon McGregor, president of T.C.A., has announced a ten per cent reduction of the airline's domestic tourist fares. He said this would reduce revenue per passenger-mile, but was expected to increase traffic volume. The new rates, which include a five per cent increase of domestic first-class fares, come into effect on January 1.

* * *

The Manchester catering firm of Smallmans, Ltd., have issued a writ against B.E.A. alleging slander. On Thursday of last week the Town Clerk of Manchester sent a letter to Lord Douglas, chairman of B.E.A., in which he referred to B.E.A.'s decision to stop using the Manchester Airport restaurant for their passengers until further notice.

* * *

Data for the two versions of the Saben Hart project depicted on the previous page are as follows: Freighter version, gross weight 3,000,000 lb; span 470ft; length 390ft; cruising speed 500 m.p.h.; operating cost per ton-mile (2,000-mile stage) 2¼d; take-off distance 5,300ft. Passenger version: gross weight 1,250,000 lb; span 353ft; length 460ft; cruising speed 660 m.p.h.; seating capacity 606; range, 3,500 miles; operating cost 2d per passenger-mile. A 1,800 passenger version of the freighter is also contemplated.

We recorded last week the unexpected news that Aeronaves de Mexico had ordered three Lockheed Electras. Here Senor Antonio Lombardo, the airline's president, signs the contract—witnessed by Senor Carlos Ramos, Aeronaves' general manager, and Mr. Glenn Waring of Lockheed. The Electra will replace 749A Constellations which are being modified for Aeronaves by Lockheed Aircraft Service (and which may well be part of the Electra deal) on the airline's medium-stage routes such as Mexico City to New Orleans.

HIGH ALTITUDE OPERATION

During recent high altitude trials the Westland Whirlwind helicopter, powered by the new Alvis Leonides Major Engine, demonstrated landings, take-offs and hoverings from a base in the Austrian Alps 11,600 ft. above sea level with seven people on board

NO OTHER HELICOPTER OF THE SAME CAPACITY HAS ACCOMPLISHED THIS PERFORMANCE

WESTLAND *The Hallmark of British Helicopters*

WESTLAND AIRCRAFT LIMITED • YEOVIL • ENGLAND

UNIVERSAL ROTARY ACTUATORS

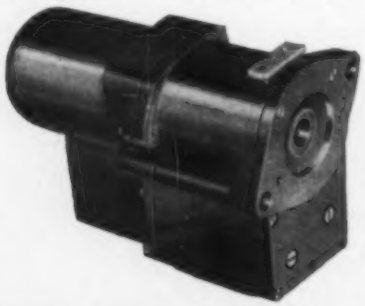
We are now in production with a Universal Rotary Actuator which greatly simplifies the work of the aircraft designer, constructor and operator.

With this design, one basic Actuator can do a wide variety of jobs—and can easily be adjusted by the customer to suit specific applications.

One and the same Actuator can be adjusted either for total rotation in either direction, or for a total angle of rotation of 180°, with a mid-stopping position, or for an angle of rotation of any lesser total than 180° (in steps of 5°) while still retaining the mid-stopping position.

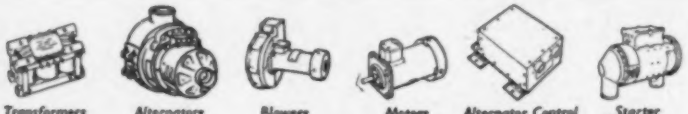
The ENGLISH ELECTRIC Universal Rotary Actuator operates on D.C. of 18 to 29 volts, has a normal loading of 50 lb. ins., and embodies a high overload capacity over a temperature range of —55°C to +150°C.

Very early delivery of these actuators can be made to meet orders. Full details and dimensions, and advice on their use, will be sent to you on request.



THE **ENGLISH ELECTRIC** AIRCRAFT EQUIPMENT DIVISION · PHOENIX WORKS, BRADFORD 3 AE24

'ENGLISH ELECTRIC' aircraft equipment



HERE AND THERE

DISC JOCKEYS in a really big way are these three gentlemen—the crew of the Soviet Mi-6 helicopter which recently lifted 26,464 lb to 7,874ft. From left to right, they are F. S. Novikov (engineer), R. I. Koprelyan (commander), and G. V. Alferov (second pilot).

Farnborough Date

NOW announced by the S.B.A.C. is the date of the 1958 Farnborough Show—from September 1-7 inclusive. As in previous years the general public will be admitted on the last three days.

Engine Export Record

BRITISH aero engine exports during July-September, figures for which have just been issued, reached a total of £10,422,133, the highest figure yet achieved for a quarterly period. It does not include engines already installed in exported aircraft.

Hendon VTOLs ?

IN a written Parliamentary reply last week, the Secretary of State for Air, Mr. George Ward, said that Hendon Airfield was "not considered suitable" for use by flying clubs and civil light aircraft. He added, however: "We see a possibility of it being used at a future date for helicopters and aircraft capable of short or vertical landings and take-offs." Hendon, as an R.A.F. station, was closed to flying on November 7.

22,000 miles by Apache

RECENTLY completed by "Mr. and Mrs. Daniel H. Walcott, Jr., socially prominent California couple, and Frank Emmert, Coca-Cola executive from Martinsburg, W. Va.," was a 22,000-mile journey by Piper Apache, combining business and holiday, which included two flights across the Atlantic and "a sweeping tour" of Europe, the Middle East, Africa and South America. The aircraft logged 140 flying hours, during which time no maintenance was required other than refuelling and one routine oil-change.

New Cessna

A FIFTH aircraft type is to be added to the Cessna range for 1958. This will be known as the Model 175 and, at an approximate price of $11,000 (£3,950), is intended to fill the gap between the 172 and 180 series. Other Cessna types currently being produced are the 182 and the twin-engined 310.

Fast Glide

AN average speed of 90 m.p.h. for a 270-mile cross-country flight in a Slingsby Skylark 2 sailplane was recently achieved by Keith Wakeman, a New Zealand crop-dusting pilot. He flew from Christchurch, South Island, across the Cook Straits to Palmerston North in North Island in 2hr 50min.

Recognition in the North

YORK Aviation Group is holding its annual recognition contest on January 11. Details from Mr. I. M. Evans, The Croft Hotel, 103 The Mount, York.

The R.A.F. Twin Pioneers

FINAL acceptance conference on the Scottish Aviation Twin Pioneer for the R.A.F. is to be held at the makers' Prestwick works towards the end of this month. The first three aircraft will then go to Boscombe Down for tests in the various rôles of bombing, supply dropping, paratrooping, freighting, ambulance and troop transport.

Tank Carrier

A SIX-WHEELED tanker weighing 13½ tons was recently shipped to the Continent in a Blackburn Beverley of Transport Command. The overhead clearance was so close that the tyres had to be deflated, and even then there was only one inch to spare in the 10ft-high cargo compartment.

Reckless Scholar

A 17-YEAR-OLD A.T.C. cadet who had learned to fly under the Air Ministry scholarship scheme was fined £5 at Petersfield for flying an aeroplane in a reckless manner, and another £5 for flying below 500ft. The prosecution followed an accident to a Tiger Moth flown by him.

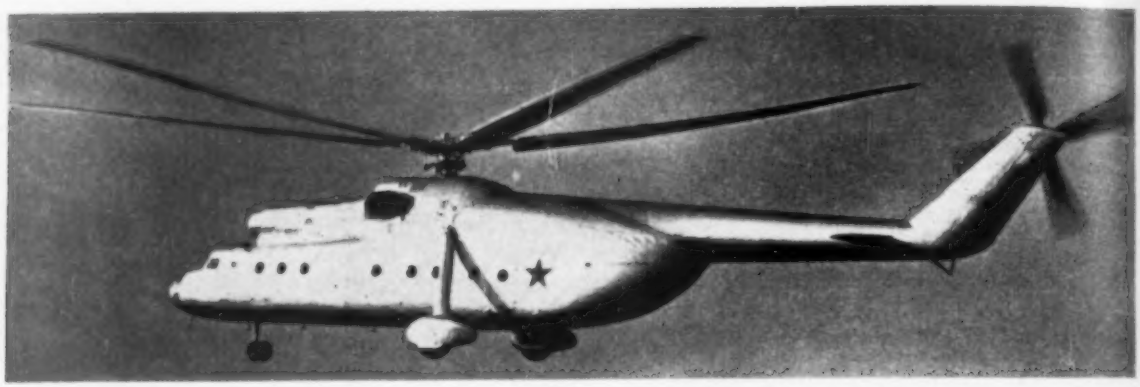
Discussing Control

THE newly formed International Association of Cybernetics—which exists to further the study of control mechanisms in machines and living creatures—is to hold a two-day congress in Namur, Belgium, on December 13-14. Discussions, in French and English, will be devoted to *The Economic and Social Implications of Automation*. Details are obtainable from the Association's offices at 13, Rue Basse-Marcelle, Namur, Belgium.

(Official photograph, Crown copyright.)

IN BLACK AND WHITE—1: A remarkable impression of night deck-landings on the carrier H.M.S. "Eagle." The long lines are the wing-tip and arrester-hook lights of approaching aircraft; the curved lines in the foreground are wingfold lights, and the blurs below them are the illuminated wands of the aircraft directors. The picture was taken by the ship's photographer, who records every landing for subsequent analysis if necessary.

IN BLACK AND WHITE—2: The smoke-tunnel technique of studying flow over an aerofoil is illustrated admirably in the photograph (right) from Fairchild. Research engineer Ray Goudis, with assistant chief of research J. S. Attinello (standing), is using a transit to measure angles of flow deflection over a blown flap.



A new picture of the mighty Russian Mi-6 twin-turbine helicopter.

AIRCRAFT INTELLIGENCE

Great Britain

Napier Scorpion-Canberra. The Scorpion-Canberra height record established by Michael Randrup and Walter Shirley on August 28 has been confirmed by the F.A.I. The homologated figure is given as 21,430 m (70,310ft).

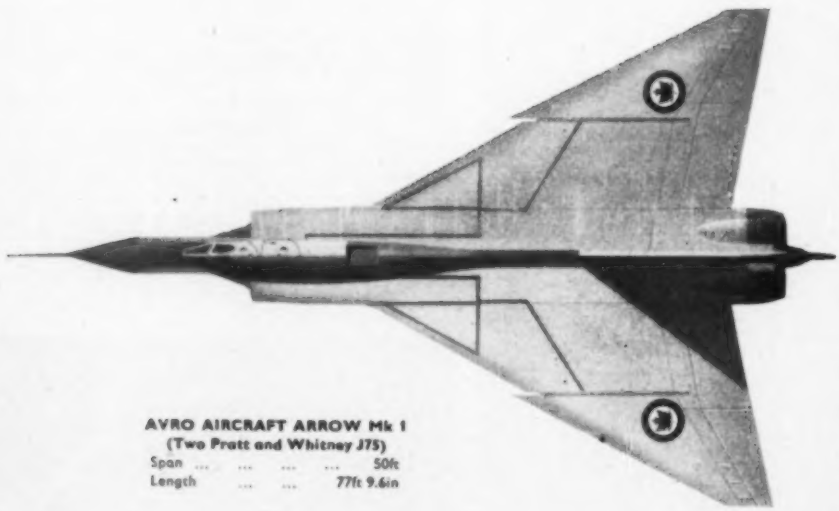
U.S.A.

Lockheed F-104 Starfighter. Originally intended to become operational last April, the Starfighter will, in fact, enter service at the end of the year. Stability and relighting troubles are said to have been cured. The first production model of the F-104B—a two-seater version of the Starfighter—is due to fly this month.

Grumman AO-1 Mohawk. This aircraft is intended for the U.S. Army and Marine Corps and exists at present only in the form of an elaborate mock-up. It has numerous interesting and appealing features. A two-seater, it is capable of 275 kt and can land and take off over a 50ft obstacle within 600ft. The engines are Lycoming T53-L-3 turboprops, each of about 1,000 h.p., and the all-up weight is 10,400 lb. Under-wing provision is made for bombs.

North American YF-108. The foregoing is the new designation of the weapon system formerly code-named WS-202A—a long-range intercepter to be developed for the U.S.A.F.

Rotor-Craft Corp. Pinwheel. During its last flight before being handed over to the U.S. Navy for evaluation, the rocket-propelled, one-man Pinwheel helicopter crashed when the power control stuck. The pilot, Dick Whittington (not related to the Folland test pilot of the same name), suffered a broken leg.



AVRO AIRCRAFT ARROW Mk 1
(Two Pratt and Whitney J75)

Span	50ft
Length	77ft 9.6in

Canada

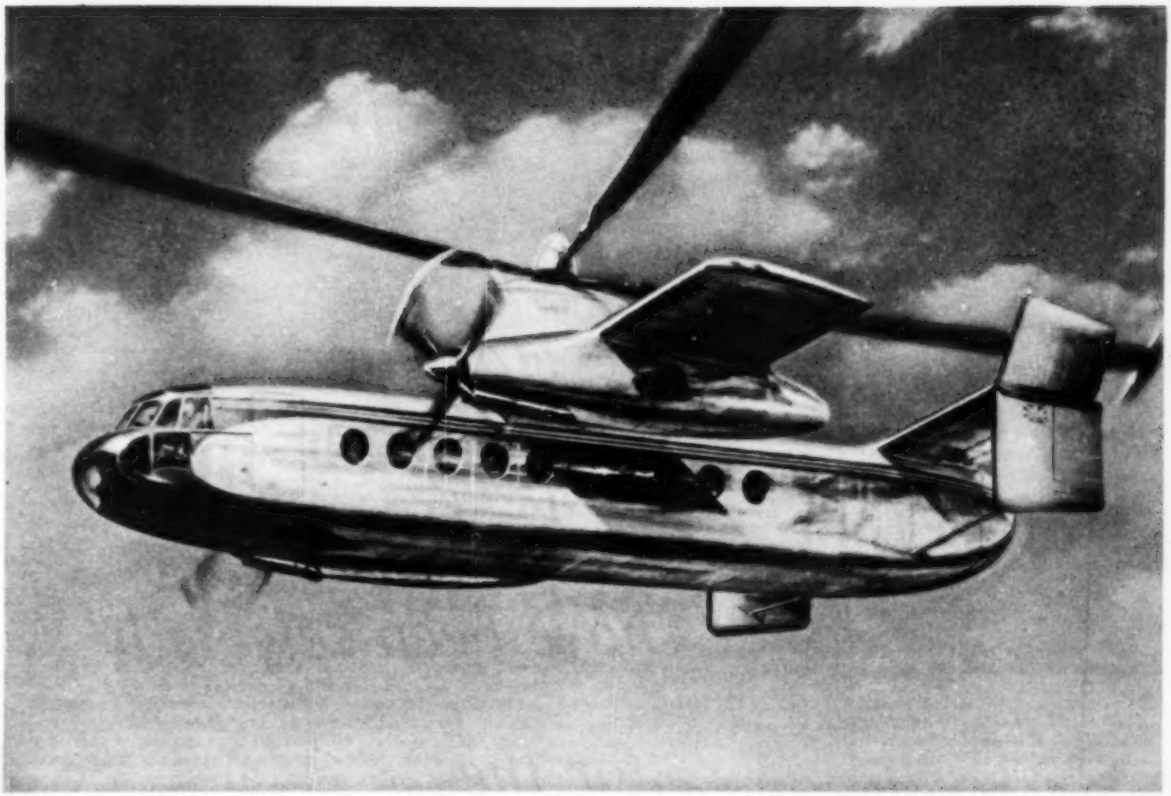
DHC-4 Caribou. The tail unit of this twin-engined transport has now been changed to a single-fin-and-rudder layout. Formerly the aircraft had twin vertical assemblies. The first ten Caribous are to be built by de Havilland Aircraft of Canada during 1959 and five will be supplied to the U.S. Army.

France

Morane-Saulnier MS.760 Paris. The Morane-Saulnier company has received an order for two MS.760 Paris four-seat twin-jet executive aircraft from the Beech Aircraft Corporation. One is for the Timken company, and the other will be used by Beech as a demonstration aircraft. Under the terms of the same contract Beech have taken an option on eight additional machines.

Italy

Fiat/Sud Aviation Collaboration. A new Italo/French co-operative project is being prepared between Fiat and Sud Aviation. It is directed towards the production of what has been termed a "super fighter". Bearing the designation 5091, this is said to be "a combination of the Baroudeur and the Fiat G91".



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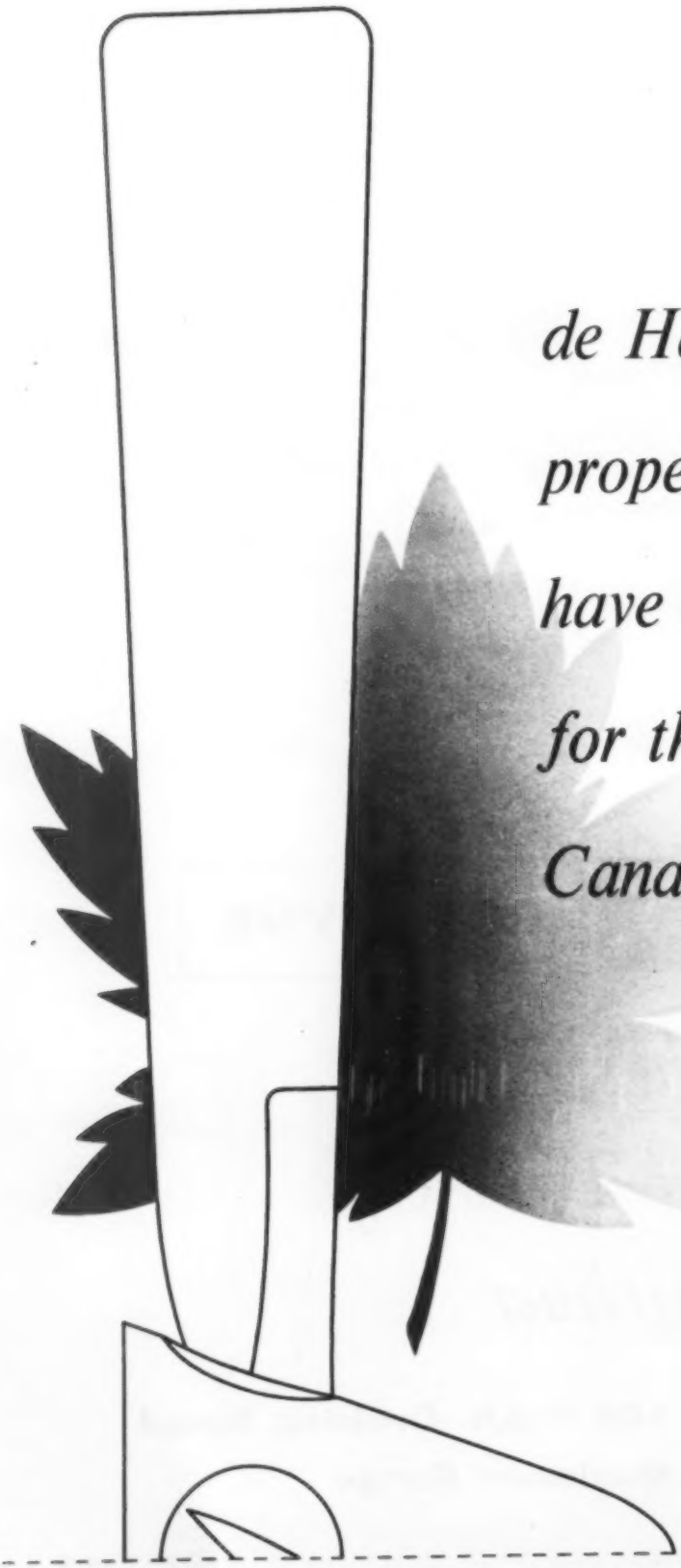

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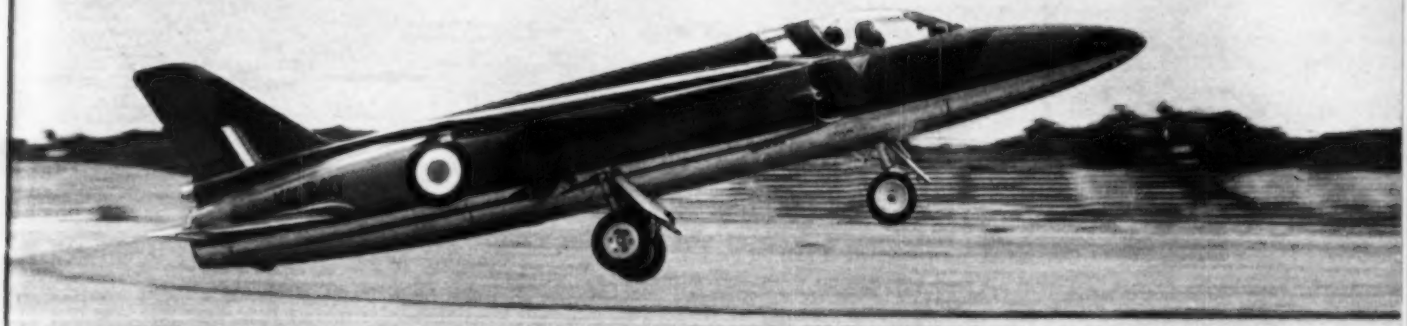


GNAT Mk I

DESIGN AND DEVELOPMENT OF THE FOLLAND LIGHT FIGHTER

I—THE BACKGROUND

THE Folland Gnat light fighter is now in production for two air forces. Wider adoption is confidently expected; a trainer version has been chosen for the R.A.F.; and development to produce a supersonic all-weather intercepter is in hand.

That is the result to date of six years of hard work, most of it as a private venture, on the light-fighter concept. The machine, now nearing its clearance for service, is a tiny single-seater with a very high rate of climb, an excellent ceiling and uncommon manœuvrability at high altitude. It has a built-in armament of two 30 mm Aden guns, and there is provision for a variety of bombs, rockets and tanks under the wings.

The Gnat is in no sense expendable, and its equipment is not rudimentary. Nevertheless, constant battle against the growth factor has resulted in a gross weight of only 6,250 lb and in a simplicity of systems and structure unrivalled by any other aircraft of comparable capability. To a great extent the present and future status of the Gnat has been assured by Bristol Aero-Engines, Ltd., whose Saturn first offered the Gnat the necessary power and whose Orpheus is now providing it. The latter engine has, of course, now also been supplied for the NATO light ground-attack fighters and for the Lockheed JetStar executive transport.

The original Gnat configuration was very different from the Gnat of today. It was based on two small, short-life turbojets with a thrust/weight ratio of about 10 : 1 and a simple on/off power control. The thrust of each was to be about 2,000 lb and the life about ten hours. A very light, semi-expendable airframe, housing a prone pilot in the nose, carrying an armament of unguided air-to-air rockets and two of these engines at the wing-tips was suggested, but rejected by Follands. The wing was to have had a thickness/chord ratio of six per cent and a sweep angle of 40 deg at the quarter-chord line.

This was just one of several projects studied during 1951. The second project was of modified layout, and a half-scale model was tunnel-tested. The third step was a radical re-arrangement, following a theory then being put forward that a twin-boom layout offered advantages in lightness. This project, therefore, had the engines in the booms, and an inverted-vee tail spanned the gap between the booms. The wing remained substantially unaltered. Much less was then known about junction design for high-speed aircraft, Mr. Kuchemann (now head of supersonics at the R.A.E.) not having completed his studies on this subject, and the twin-boom layout was not continued.

Though the twin booms were discarded, the two engines were retained at the mid-semi-span position in several other projects; and two of these schemes are illustrated on the following page. Engine nacelle arrangements varied, as did horizontal tail layout; and the later machine had an undercarriage consisting of a single mainwheel, in the fuselage, supported by two outrigger wheels retracting into the engine nacelles. Armament of this version consisted of rocket pods in the nose and at the wing-tips. After the first project the prone position for the pilot was discarded in favour of a conventional seat.

The first design which is recognizable as a direct ancestor of the Gnat is the project dating from about September 1951. This had two of the short-life engines placed side-by-side in the rear fuselage and a "T" tail of delta plan-form. The makers were considering the possibility of pitch-up and the tailplane was therefore raised in this way to keep it clear of the wing wake. A dorsal spine was also included and the intakes were for the first time in the fuselage flanks.

Follands had conceived a method of attacking a bomber in which the fighter would pull up from below and ripple a stream of rockets along the bomber's track. The rocket pack was in the fuselage. Another feature was that the mainwheels were to be retracted into fairings aft of the intakes. The Gnat as we know it today was definitely taking shape.

Because the small short-life engines, having only one power setting, gave rise to severe limitations in handling and flexibility, Follands abandoned them in favour of a Bristol engine which was then being prepared for another project. This engine was the BE.22 Saturn, with a thrust of 3,750 lb. The installation, with intakes under the wings in the fuselage flanks, remained substantially unaltered and the dorsal spine was retained, but the high delta tailplane was changed to a swept surface. The wing was substantially that of the present Gnat, but outboard ailerons were still planned. Armament now consisted of either a rocket pack or twin Aden guns in a compartment behind the cockpit, with the possible addition of eight 60 lb air-to-ground rockets on four underwing pylons. The design was designated Folland FO.140/1.

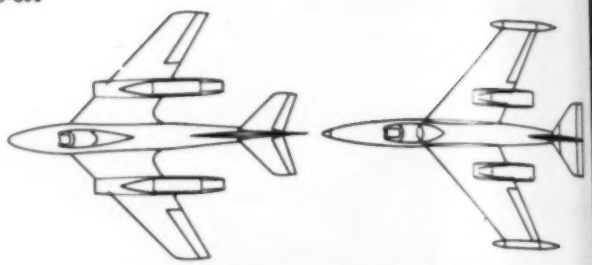
There were still some doubts about the availability of the Bristol engine and Follands therefore prepared a second version of the FO.140, powered by a Rolls-Royce Derwent, calling it FO.140/2. Tip-tanks were added so that fuel capacity was 200 gal; and 200 rounds of Aden-gun ammunition were to be carried. The dorsal spine was omitted. In performance, the Derwent would have given the Gnat a take-off as good as that with the Saturn, but top speed and high-altitude performance would have suffered.

Meanwhile, development of the airframe continued and a number of important changes were made. The problem of pitch-up was again raised when some other companies resorted to a low-mounted tailplane. The North American F-100 and the English Electric P.1 both had this arrangement, but Follands still hoped to achieve the desired results with a high-set tail. Nevertheless, following a visit by Mr. W. E. W. Petter to manufacturers in the U.S.A., both the structural and aerodynamic characteristics of the low-set unit were better understood and a final decision in its favour was made for the Gnat. Further study of the gun installation showed that if the guns were placed low down in the fuselage, as was dictated by the gun-pack layout, firing could cause strong pitching moments at high altitude. The guns were therefore brought up into the fairings flanking the fuselage so that the barrels lay along the aircraft datum. In order to keep the air intakes clear of the wing, these were also brought forward to about their present position and the guns were arranged to fire

The heading picture shows one of the M.o.S. Gnats taking off at the S.B.A.C. Display last September. Initial acceleration is tremendous; take-off runs of about 300 yd have been achieved with the Gnat, and the climb from "brakes off" to 45,000ft takes well under five minutes.

GNAT Mk 1 . . .

***PRIVATE VENTURER:** Designer of the Gnat was Mr. W. E. W. Petter, C.B.E., B.A., F.R.Ae.S., who joined Folland Aircraft in October 1950 as deputy managing director. In July 1951, on Mr. Folland's retirement, Mr. Petter became managing director (he was, in effect, technical director as well). In early 1954, when Mr. F. H. Pollicutt left the company, Mr. Petter assumed the titles of managing director and chief engineer. He is seen on the left.*



1 and 2, projects of early 1951, with two short-life engines and rocket armament

through the intake lips. The idea of using the undercarriage doors as airbrakes was also conceived and the present Gnat windscreen and canopy were developed. All these features are shown in the last plan view (opposite), which originates from May-September 1952. The engine there shown is the B.E. 26 Orpheus.

The great blow came when, in autumn 1952, the Saturn was discontinued. Follands considered a great many alternatives, including the Turboméca Ossau, which itself never materialized, but none really filled the bill. The Gnat was sadly in the doldrums; but the company did not despair and continued to try to persuade Bristol to continue development. In the meantime a Viper installation was prepared in order to get the airframe into the air. While construction of the Viper-powered machine, then called Midge, was proceeding during 1953, a Bristol engine project was revived as a private venture and the larger and more powerful Orpheus emerged. The Gnat fuselage was therefore widened by four inches aft of the intakes and the wing area was increased from 126 to 136 sq ft.

The first flight of the Midge was made by "Ted" Tennant from Boscombe Down on August 11, 1954. It first had outboard ailerons and manual controls with a trimming tailplane, but some flying was later done with the Hobson screwjack moving the tailplane as an "all-flying" surface in direct response to mechanical actuation of the elevator. In all, the Midge flew for 109 hr before it was destroyed at Chilbolton in a take-off accident while being flown by a Swiss pilot on September 26, 1955. Altogether 21 pilots flew it.

At about this time, Follands were again investigating the six per cent wing. An eight per cent surface had been adopted for the Gnat because it was then easier to build and gave better low-speed characteristics. Aeroelastic properties of the thinner wing were such that an inboard aileron offered much greater effectiveness in the high-speed, low-level case and, since Follands were interested in the NATO ground- attack fighter specification (which they had, in fact, initiated), they decided to standardize this arrangement. An eight per cent wing with inboard ailerons was accordingly made and flown on the Midge in February 1955.

On July 18, 1955, S/L. Tennant first flew the Gnat prototype, G-39-2, from Chilbolton. This began the flight development of the Orpheus which was then rated at 4,000 lb thrust; and it behaved extremely well.

Evaluation of the Midge showed that the angle of attack during the approach was rather high, impairing the pilot's vision. It was therefore decided to droop the ailerons some 20 deg by a direct mechanical linkage with the main undercarriage legs. The geometry of this system proved quite a design headache, but the result is that, not only do the ailerons droop only when the undercarriage comes fully down (virtually not at all in the intermediate airbrake setting), but the available aileron travel is considerably increased in the drooped position. The ailerons were by now fully powered, and the drooping linkage operated the jack valves.

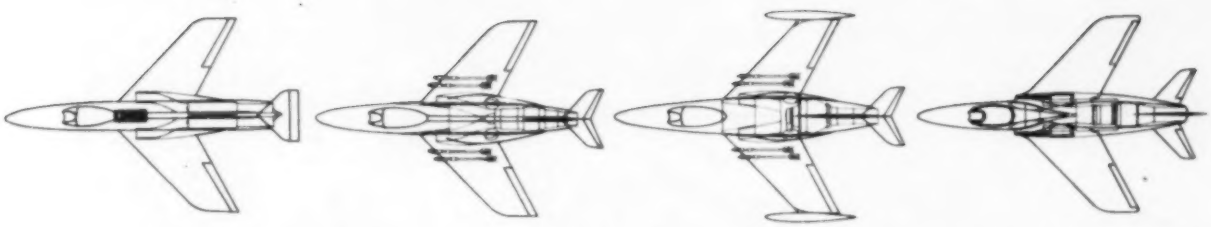
Though not specifically planned, the Gnat turned out to be substantially area-ruled for transonic flight and the drag rise associated with this regime occurred very late. Even with later versions, the area rule as such is not applied, but the cross-sectional area of the wing constitutes so small a proportion of the total cross-section that the rule is substantially fulfilled. Further steps could be taken but are not thought imperative. Follands consider that these might entail reducing fuselage volume around the wing trailing edge rather than adding bulges elsewhere. The latter course is felt to offer little advantage; and this was indeed noted with the experimentally-bulged Hunter. With the present Orpheus of 4,850 lb thrust, the Gnat has a very high thrust/weight ratio which gives it good load-carrying capabilities and interception performance.

As for later Gnats, referred to as the Mk 2 and Mk 4, the new six per cent wing, a section of which has been shown at Farnborough, will allow high supersonic speeds in level flight; and some form of afterburning has also been specified. Follands are now developing the wing along current lines with extensive high-lift devices on both leading and trailing edges. Flap blowing will be included if necessary and aileron position may be changed for this reason. These developments are aimed at increasing the available lift for the purpose of operating from both small land bases and carriers. The aerofoil section of wing and tail surfaces of the Gnat Mk 1 is the R.A.E. 102 which was chosen as offering a good compromise between high lift and high Mach number capabilities without the need for special high-lift devices.

Another Gnat development is the tandem-two-seat Trainer which has been chosen by the R.A.F. Because of its specialized application, considerable changes have been introduced. It is a rather more sophisticated aircraft, designed for a very long service life and is equipped, for all-weather flying, with the new advanced blind-flying instrumentation, engine de-icing and other features. The fuselage is lengthened by nine inches and, in order to make allowance for student pilots and to facilitate operation from small airfields, the wing has been considerably altered. Available lift has been increased by extending the area and by providing split flaps in conjunction with outboard ailerons. The split flaps give at least as great an increase in lift as plain flaps, but also provide drag, which is most useful in giving the pilot better control of the rate of descent on the approach. The thickness/chord ratio has also been reduced to seven per cent in order to maintain the high-speed performance of the Gnat fighter. Internal fuel load has been increased to 260 gal by fitting tanks in the wing torsion box out to half of each semi-span. The controls remain the same as those of the Gnat, but the area of the tail surfaces has been increased and particular attention has been given to providing docile stalling and spinning characteristics. In this respect the low tailplane of the Gnat has already given excellent results. The Orpheus engine for the trainer will be slightly de-rated to give 4,280 lb thrust, and will have an acceleration control. Liquid oxygen will also replace the present gaseous system.

Folland have developed their own ejection seat, based on a Saab

A striking view of the Gnat which has been flown with underwing stores. The load is two 66-gal tanks and 12 three-inch rockets.



3, twin-engined Gnat of September 1951; 4, Saturn Gnat Fo. 140/1; 5, Derwent Gnat of early 1952; 6, the first Orpheus Gnat design of mid-1952, with low-set tail, forward intakes, Gnat canopy and guns on the centre line.

design, and have carried out a full test programme with both live and dummy ejections from a Meteor 7. Seats now fitted in Gnat Mk 1s are fully automatic, have leg-restraint and combined harness and are capable of operating effectively over the whole flight envelope of the Gnat. The performance has already been convincingly demonstrated in emergency when S/L. Tennant ejected from the first Gnat at very high speed and fairly low level after a tailplane failure. He landed uninjured. Because of its small size and lightness, the Folland seat was also chosen for installation in the Short SC.1 VTO aircraft, and for the Trainer, a telescopic gun is being developed to give very high ejection velocity.

FLIGHT TESTING THE GNAT

By S/L. E. A. Tennant

SPECIALLY written for "Flight" by the chief test pilot of Folland Aircraft, Ltd., the notes below give an idea of the wide field of investigation involved in the flight development of a new aircraft such as the Gnat. The author's views on pleasing the pilot in laying out the cockpit are of particular interest.

WE have been flying Gnats at Chilbolton since July 1955 and during the year before that we had over a hundred flying hours out of the invaluable Midge. By next June we hope to have completed nearly six hundred hours' flying and to have cleared the aircraft completely for Service use. This period of testing has not been without excitement. It has always been intensely interesting, partly because of the philosophy behind the design of the aircraft and partly because the Gnat is Folland's first complete aircraft.

The five aircraft ordered by the Ministry of Supply have each been allocated part of the total test programme. One is on gun-firing tests, the next on engine development work, another on flight flutter, and so on. Instrumentation plays a large part in obtaining the answers and each Gnat has its nest of Hussenot recorders, which must be freshly loaded for each flight. On the gun-firing aircraft recordings are taken on over seventy channels, so the importance of serviceable instrumentation needs no emphasis.

The development of the flying controls is worth mentioning, because several changes have taken place since the Midge first flew with manual outboard ailerons, manual elevators and rudder. These changes have led us ultimately to adopt inboard ailerons, power operated, which droop 20 deg and act as flaps when the undercarriage is lowered. Flutter considerations have led us to modify the tail to a fully powered slab, which is at present undergoing flight tests.

In my experience, flutter flight-testing demands more concentration than any other part of the programme. The weather conditions must be ideal, without even slightly bumpy air. Speed is increased very gradually on each flight and the results have to be examined before proceeding to the next. Near the critical speeds the increases are of the order of 2 to 5 knots, or Mach 0.01. During each flight a vibrating device which hammers the tailplane at various frequencies is switched on. From the recorders which pick up the tailplane responses the frequencies which cause resonance are picked out from a sweep over the frequency range. Excitations at these frequencies are then applied to the tailplane and stopped abruptly. The decay or damping-out of the excitation is recorded, and so on throughout the high E.A.S. range and the high Mach number ranges until the flight envelope is covered.

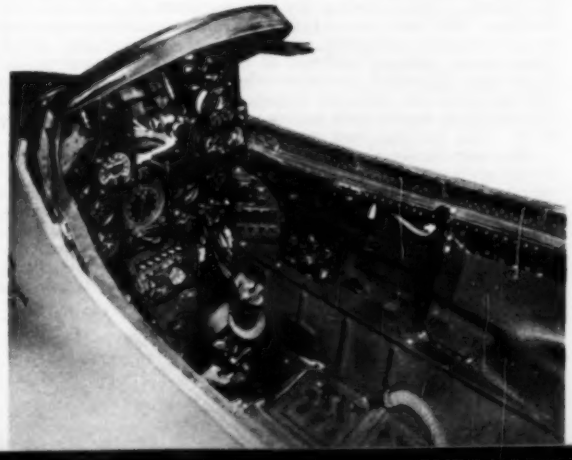
More humdrum, but nevertheless very important, are fuel consumption tests, drag measurements (with and without underwing stores), and many other tests. An important point to remember is that most of the Bristol Orpheus development work has been done in Gnat aircraft. This engine with its first-class thrust/weight ratio pushes us aloft to 45,000ft in well under five minutes—not just from attaining best climb speed, but from "brakes off." Once aloft there is no fighter aircraft flying in England with the Gnat's manœuvrability; and with the slab tail there is no noticeable loss of tailplane effectiveness, either transonically or supersonically. Manœuvre and thrust boundaries have to be measured; and, concurrently with these checks, tests of cabin heating, cooling and pressurization are made.

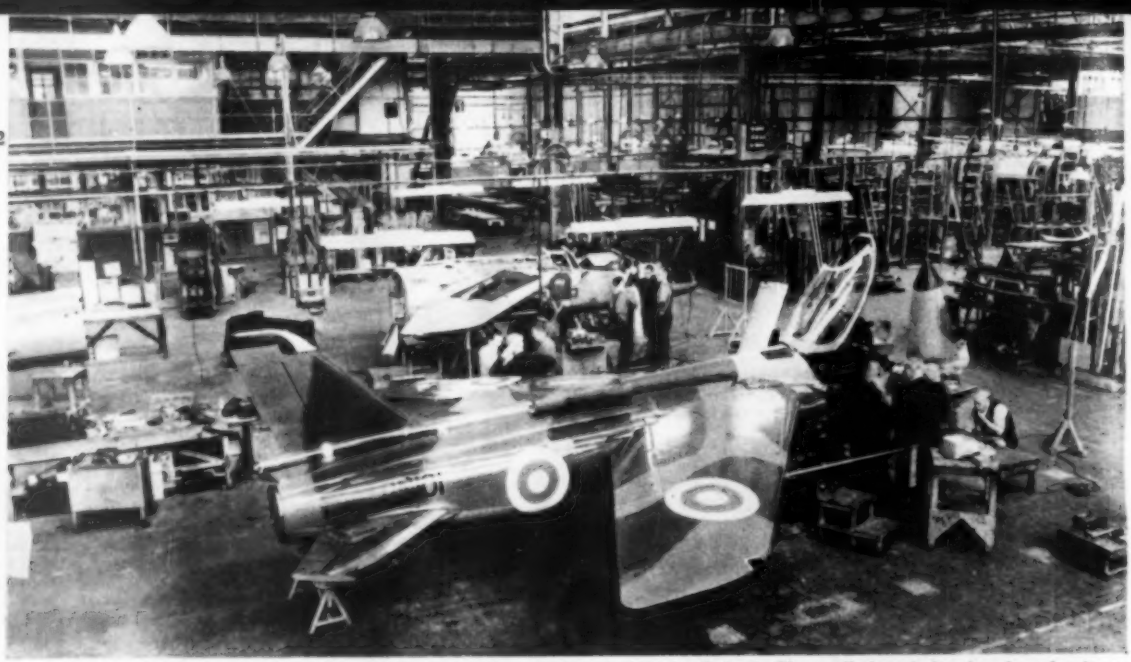
With the possibility of the Gnat trainer going into R.A.F. service, spinning characteristics need careful checking. Preliminary work has revealed no vices in spins up to three turns in both directions. Take-off and landing distances need careful checking, as do visibility in rain, accessibility of all switches and knobs in the cockpit, and a host of minor things which all contribute to making a good aeroplane. In my opinion, there is no switch or control in any cockpit that does not warrant extremely careful positioning. A pilot must feel at home, and he should be able to reach everything without hesitation or fumbling. For example, the throttle box was changed three times before we decided that its present position could not be bettered. Warning lights have been repositioned several times, and so on. It is very easy to sit in a mock-up and say where you *think* the various switches and knobs should be, but it is only the result of flight experience that you know. From observation of my friends I have found that, given the chance, ten pilots would produce ten different cockpit layouts. Very probably, too, each pilot would be critical of the next man's choice. Equally, if shown an ideally planned cockpit, the same ten would be unanimous in their approval of it. Pilots do not seem to know exactly what they want before the hardware is made, but they do instinctively recognize the best when it is offered. In these days, when emphasis is on production with minimum modification, it takes patience and tact to explain to a draughtsman that he could possibly better his first attempt at this or that item! I can honestly praise our team for the co-operation they have shown with fickle pilots.

Ultimately the numerous tests dovetail together rather like a jigsaw puzzle and in our case we shall see the result in the final development Gnat, which will have all the modifications and no restrictions. It will be able to fire its guns high up at low speed or low down at high speed, and carry bombs, rockets and tanks and any other appendages that untidy minds can devise. No doubt by that time fertile imaginations will have dreamed-up some more highly improbable conditions, and so another test programme will be born.

All this is not the complete Gnat picture by any means, but merely a sketchy outline of what is going on in our flight development department. We still have to undergo tropical trials to the satisfaction of the Indian Air Force and early next year we look forward to starting a fresh programme in Cawnpore.

An M.o.S. Gnat cockpit, showing the layout of the blind-flying instruments below the gun-sight mounting, which is flanked by D.M.E. dial and engine instruments. General switches are on the central console. Power lever and undercarriage control are not visible.





Final assembly of Gnats at Hamble. The machine in the foreground is the first for Finland. The small size of the aircraft makes it particularly easy to work on without staging. Note dielectric nose-cap and deletion of rearward-vision windows.

GNAT Mk I . . .

ANATOMY OF THE GNAT

TO a consideration of the structure of the Gnat one might very well apply that overworked but effective American term, systems concept. It is a delicate blend of the demands of structural efficiency, with extreme compactness, as the drawing overleaf shows.

Although large-scale forging and machining can be expensive in plant and material, they normally pay dividends in structural economy. Though machined skins might be considered the prerogative of heavy aircraft, the Gnat contains several examples. Follands point out that, since doubling is required in parts of the wing skin, some constructors of Gnats under licence might find it just as cheap to set up a skin-milling plant or chemical etching equipment as to install a Reduxing plant, which is the alternative. These firms may make their own choice, but Follands themselves are turning to machining. Of ease of access (and therefore of repair), Follands have nowhere lost sight; and one of the main factors in achieving this goal is, indeed, the universal simplification of systems—with no attendant lessening of their effectiveness—which is at the root of the design-thinking behind the whole project.

The Gnat, then, is—basically at any rate—simple. The wing of the Mk 1 is in fact almost wholly given over to providing lift and does not house more equipment than is required for underwing armament and drop-tanks. Neither wheel-wells nor internal tankage complicate it; and even the aileron actuating gear is housed in the fuselage. But the fuselage is a rather different case. Here every member has more than one function. No one frame is like another, no space is left unused, no panel is unstressed unless it is meant to be removed quickly and frequently. Yet nowhere is accessibility sacrificed. Every component can be reached easily, if only because it has perforce to be installed close to the outer skin of the structure. The fuselage is something of a technical writer's nightmare, but it may well prove the maintenance engineer's dream.

A continuous structure passing through the fuselage, the Gnat wing is made up of two main planes permanently joined to a carry-through structure. It is based on a two-spar torsion box which picks up the fuselage by four bolts, disposed longitudinally in order to avoid passing bending moments directly into the fuselage. Ribs both fore and aft of the rear spar are aligned normal to it for ease of production; and those of the leading edge, which adds to the torsional stiffness of the wing, are normal to the front spar. Extruded Z-section stringers lie spanwise, parallel to the rear spar; and separator fittings at the rib/stringer junctions take the compressive loads between the wing skins under bending loads. The material most generally used is D.T.D.546.

The spars are simply made up from 12 s.w.g. plate formed by a power press tool into channel section, the inboard portion of the rear spar being stiffened by a second 10 s.w.g. channel section riveted to it back-to-back. Interspar ribs are plate pressings, flanged all round and with flanged lightening holes. The spanwise stringers pass through cut-outs in the flanges; and the separator fittings pick up the stringers at these points, being riveted at the top and secured with blind bolts to welded fittings at the bottom. Spar/rib junctions are riveted. Stringers aft of the rear spar, where the wing supports only air loads, are of L section, with their horizontal faces riveted to joggled portions of the rib flanges. The trailing edge is formed by a sheet wrapped round the ends of the ribs. The outboard end of the main wing structure is a pressed closing rib, to which the detachable, built-up tip structure proper is fastened by spigots.

Two pylons in each semi-span are based on fork lugs which are part of magnesium zirconium castings ahead of the front spar. Three bolts in each lug take the load, while further castings within the torsion box locate the aft portion of the pylon between special ribs. Pipes and leads are disposed in the leading edge and are accessible through circular panels adjacent to each pylon.

Like the other control surfaces, the ailerons are of conventional built-up structure, skinned with 22 s.w.g. sheet inboard and 20 s.w.g. outboard. Tubes in the leading edges carry lead mass-balancing and the operating levers are magnesium zirconium castings bolted to the inboard end of each surface.

Initially the torsion box skin had a 12 s.w.g. doubler over approximately half of the chord, the doubling being projected along stringer and rib lines. The two skins were Reduxed flat and then rolled to contour. Now Follands are to machine a single skin to the same thicknesses and then roll it. All wing-skins are riveted to the supporting structure, 16 s.w.g. with 20 s.w.g. doubling near the spar being applied to the leading edge and 18 s.w.g., with an 18 s.w.g. doubler in parts, aft of the rear spar.

Each wing abuts on a root rib, having sheet webs bolted to extruded T-section booms which are stretch-formed to the aerofoil contour. Skin edges are bolted to these and covered in turn by butt straps formed to take both aerofoil section and anhedral angle. Special fittings carry the stringers through the ribs. Die-forged fittings join the root rib webs with the channel section spars and also hold the bolts attaching the wing to fuselage frames 12 and 16. A doubler skin (or machined extra thickness) reinforces the skin aft of 50 per cent chord at each surface of the carry-through structure.

The wing picks up the fuselage through the main forgings at frame 16 and the webs of frame 12, by four bolts parallel to the fuselage centre-line. The bolts screw into the fittings in the root ribs but are located inside sleeves which themselves carry a nut at their outer end. These sleeves provide a good tight fit and avoid movement and fretting under heavy flight loads. The nuts act as extractors as well. Main wing loads are taken by the rear spar and by the forgings at frame 16. The lower butt strap in each root rib is bolted to the magnesium zirconium shear wall in the fuselage. Frames and skinning completing the fuselage over the wing are a permanent part of the carry-through structure, the skin being bolted to adjoining sections fore and aft of it to carry end loads caused by bending moments originating at the tail. There is no access to the wing torsion box, but the aileron hinge fittings are detachable and therefore offer easy aileron repair and servicing.

The Gnat fuselage is a conventional frame-and-stringer, stressed-skin monococque supported by two vertical shear walls and four main longerons, but many of the frames act also as bulkheads and only three of them are anything like identical. Each one earns its keep. Of the original total of 30, one has been eliminated—and, say Follands, it is pure coincidence that this should have been No. 13. Co-incidentally the elimination occurred at about the time that the first Gnat orders were placed.

Of the 29 remaining frames, Nos. 4 and 8 mark the limits of the pressure cabin, while Nos. 12 and 16 enclose the gun bays, hold the wings, support the main undercarriage and enclose one of the fuel tanks. The forward part of the engine is housed between frames 18 and 22, engine loads being taken primarily at No. 22. At this point the fuselage is broken for engine installation and removal. The Gnat can be carried on a lorry with only the wing-tips removed to keep within legal width limits.

To form the break, frame 22 is duplicated, the two sections being called 22A and 22B. The latter carries a steel firewall. Eight spigots and nuts serve to join the two halves, the inner four picking up longerons in the main fuselage and the outer four picking up in the fairings. A magnesium zirconium pressed-sheet shear wall extends from frame 12 to 22, enclosing the main fuselage space and leaving the outer skin around the fairings substantially unstressed. The strength of the wall obviates a number of stringers in the tank bays in this area, so making the contours of the bag tanks less complex.

Considerable use is made of magnesium castings. In many instances the minimum casting thicknesses are used; and, where even smaller thicknesses would suffice, magnesium saves weight. In all cases magnesium units are given an epoxide stoved finish which is exceedingly tough and durable and should have admirable corrosion-resistant properties.

Frame 26 is inclined to the vertical and picks up the front spar of the fin. Frame 27 picks up the fin centre spar; and diaphragms between the two serve as the inner walls of the two boxes which support the magnesium castings bearing the tailplane pivots, each in two ball bearings.

There are four longerons, two of them extending from the nose, along the edges of the tank floor to frame 22 and two more running from frames 17 to 22 at the 10 o'clock and 2 o'clock levels. All four hold fuselage-break spigots. The lower segments of frames 10 to 22A are flattened to support the single-piece main tank floor, the outer contour being taken by detachable panels. An underfuselage trough is thus left clear to take control runs, piping, cables and certain components of the fuel and hydraulic systems.

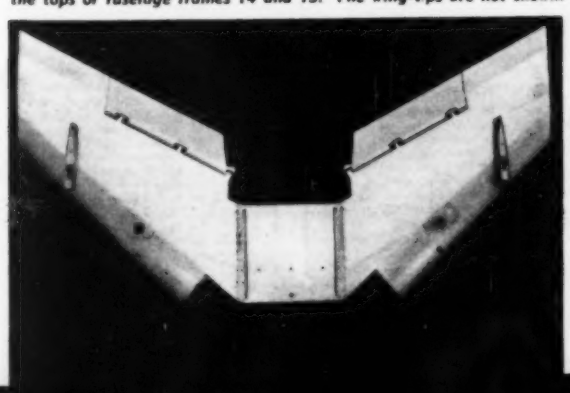
The engine air-intake ducts are made out of hot-pressed halves of magnesium zirconium, welded together and held in the main frame structure, but bearing no structural loads themselves. They begin just forward of frame 9, outside the skin which is the main shear member at this point, and pass inwards through the shear wall between frame 10 and 16, forming a cylindrical section with a central dividing wall up to the engine intake lip at frame 18. The profile of the intake fairings is continued aft alongside the fuselage proper to form a housing for the guns and main undercarriage units and for two fuel tanks just forward of frame 22A. The fairings are closed transversely by the steel firewall at frame 22B, but continue alongside the fuselage right to the tail, providing housing for the tailplane attachment and sundry other equipment.

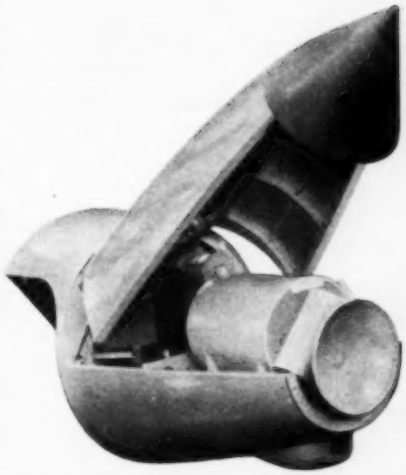
The nose cap and the top of the nose to frame 4 open upwards, the flight loads when closed being taken by toggle fasteners. Frame 4 carries the hinge and forms part of the forward pressure bulkhead. Having a D.T.D.610 web ¼in thick, it also acts as the forward armour protection for the pilot. The equipment bay is extended aft through the upper portion of frame 4 to provide an extra shelf for equipment; and the vertical pressure bulkhead is completed just ahead of frame 5. This unit is termed frame 5A and forms the forward anchorage for the magnesium cast windscreen frame.

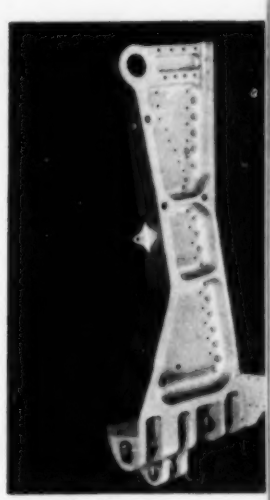
Made by Triplex, the windscreen is a conventional laminated, dry-air sandwich unit with an outer layer ¼in thick, separated by a ¼in airspace from the bullet-proof and pressure-retaining 1¼in-thick laminated inner layer. The magnesium frame holds the glass and provides a channel for the inflatable-rubber canopy seal, the whole being supported by extensions of the casting reaching forward to frame 5A, as stated, and downward at an angle to a point on frame 6 on the fuselage datum. Frame 5 is broken at the top to accommodate this casting.

The canopy, which is of the clam-shell type and hinged at the rear, is of Folland's own manufacture. It is a single ¼in-thick blown plastic unit, the edges of which are cemented with high-temperature "dough" to glasscloth strips, to which in turn are bolted the metal flanges mating with the canopy seal. Since the windscreen is cantilevered the canopy fits round it and no quarter lights are needed. A tie bar, fitted across the front of the canopy and lying ahead of the screen when the canopy is closed, has the sole function of preventing premature disintegration after jettisoning.

The underside of a Gnat wing, showing the tapered torsion box and carrying-through structure, the latter having holes for spigots locating the tops of fuselage frames 14 and 15. The wing-tips are not shown.







Above, a radar-ranging installation shown by Folland at the last S.B.A.C. show. Right, the forging which, at fuselage frame 16, holds the mainwheel leg and oleo, sequence valve, wing rear spar, aileron servo, aileron-droop pulley and rear gun mounting.

An important structural unit, the coaming is built up from plate sections and extruded magnesium beams running from the sloping rear pressure-bulkhead forward to frame 4. It is continued aft by the longeron running back to frame 12. Two canopy-locking hooks, controlled by a hand lever, are located in castings at the top of frame 6.

Frame 8 merely locates skin and stringers, the main structural task at this point being performed by the sloping pressure-bulkhead which supports the canopy hinges, the ejection-seat rollers and the nosewheel leg mounting. Rearward-vision windows have now been deleted. The top of the bulkhead is supported by the arched panel which forms a stressed cover for the equipment bay. This stressed panel also completes frame 9, which is interrupted by the bay opening. The tie bar which crosses the intake to locate the forward end of each gun blast-tube is held by frame 9. The intake fairing is largely unstressed and shear loads in the fuselage are taken by the magnesium shear wall which continues the skin line of the forward fuselage back to frame 22.

Underneath the equipment bay floor is attached the built-up arch which holds the nosewheel radius arm and jack. The leg itself is a magnesium casting (by British Messier); and the compression oleo is attached slightly below the leg pivot, giving a pre-retraction effect as the leg retracts. Being also an airbrake surface, the door is permanently attached and does not move relative to the leg. A smaller fairing door is operated by cable and pulley from the nosewheel leg.

Follands arrived at a neat anti-shimmy device for the nosewheel and saved 10 per cent in weight in the process. They forged their own nosewheels, with split rims for easy tyre removal, having a coned web only 0.1in thick. The two wheels are located, eight inches apart, on a tapered axle, and tightened home by torque-loaded nuts, without any spline or key, thus avoiding stress concentrations. Since they are rigidly coupled, the wheels give excellent anti-shimmy protection. A pair of them has successfully completed over 10,000 miles on the Dunlop spinning rig.

Frame 11 supports the gun barrels and stiffens the No. 1 fuel tank bay walls. The lower segments of frame 10 to 18 are flattened to hold the single-piece tank floor, and the space below them provides stowage for control cables, fuel piping, undercarriage selector valve and fuel-flow proportioner. The long panel which covers the whole space is unstressed.

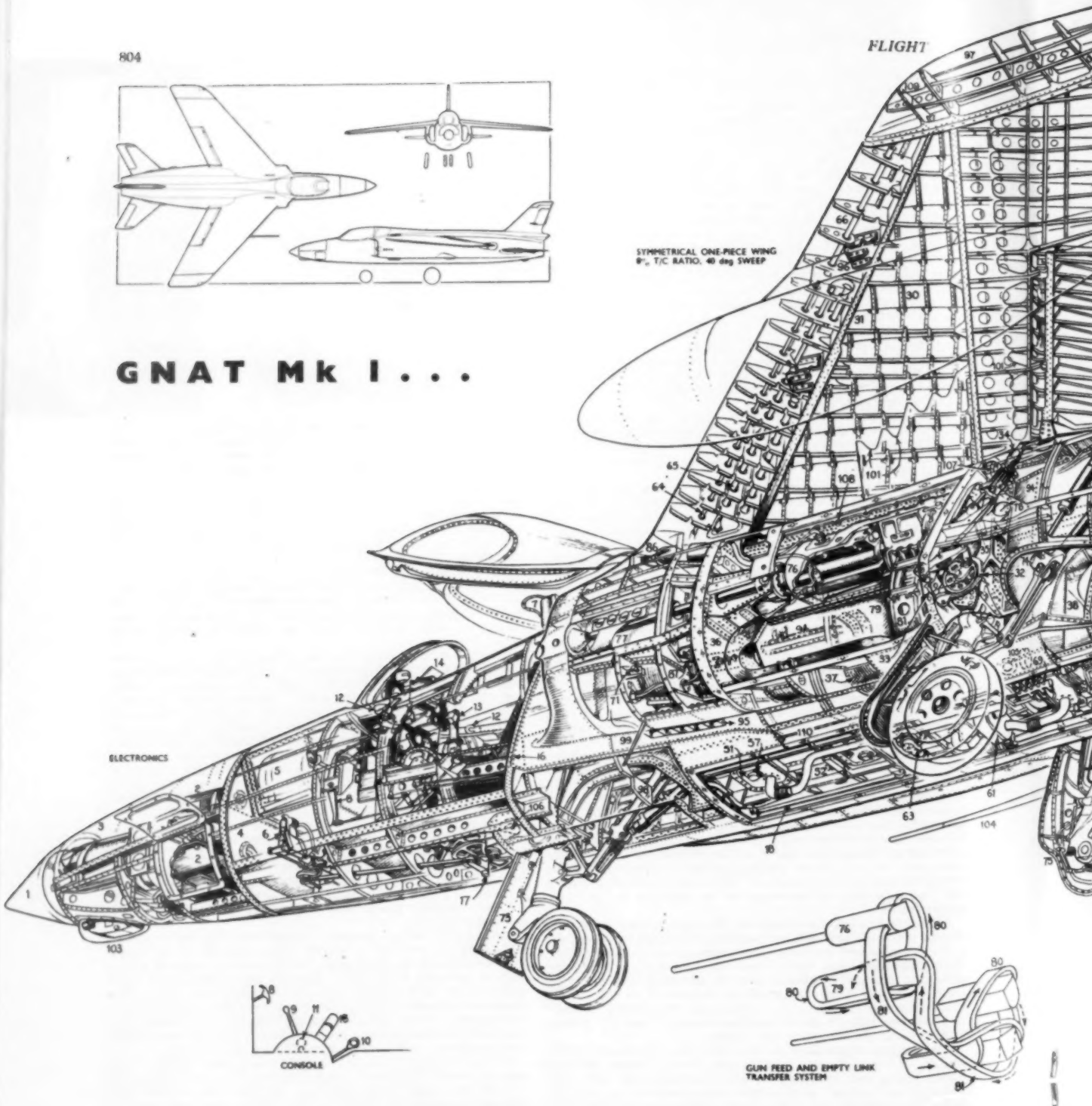
The magnesium intake ducts are made in sections between frames 9 and 12 and between 12 and 16, where the ducts merge into a single cylindrical section. A flexible joint at this point stops the ducting working with the fuselage under load. The cylindrical section has a dividing wall to prevent the engine air entering at one intake and turning to flow out through the other.

Since 13 has been eliminated, frames 14 and 15 are located, evenly spaced, between 12 and 16; and their main task is to locate the ducts and stiffen the tank walls against pressure loads. They are not complete at the top, their three webs being located by spigots in holes in the under-surface of the wing carry-through.

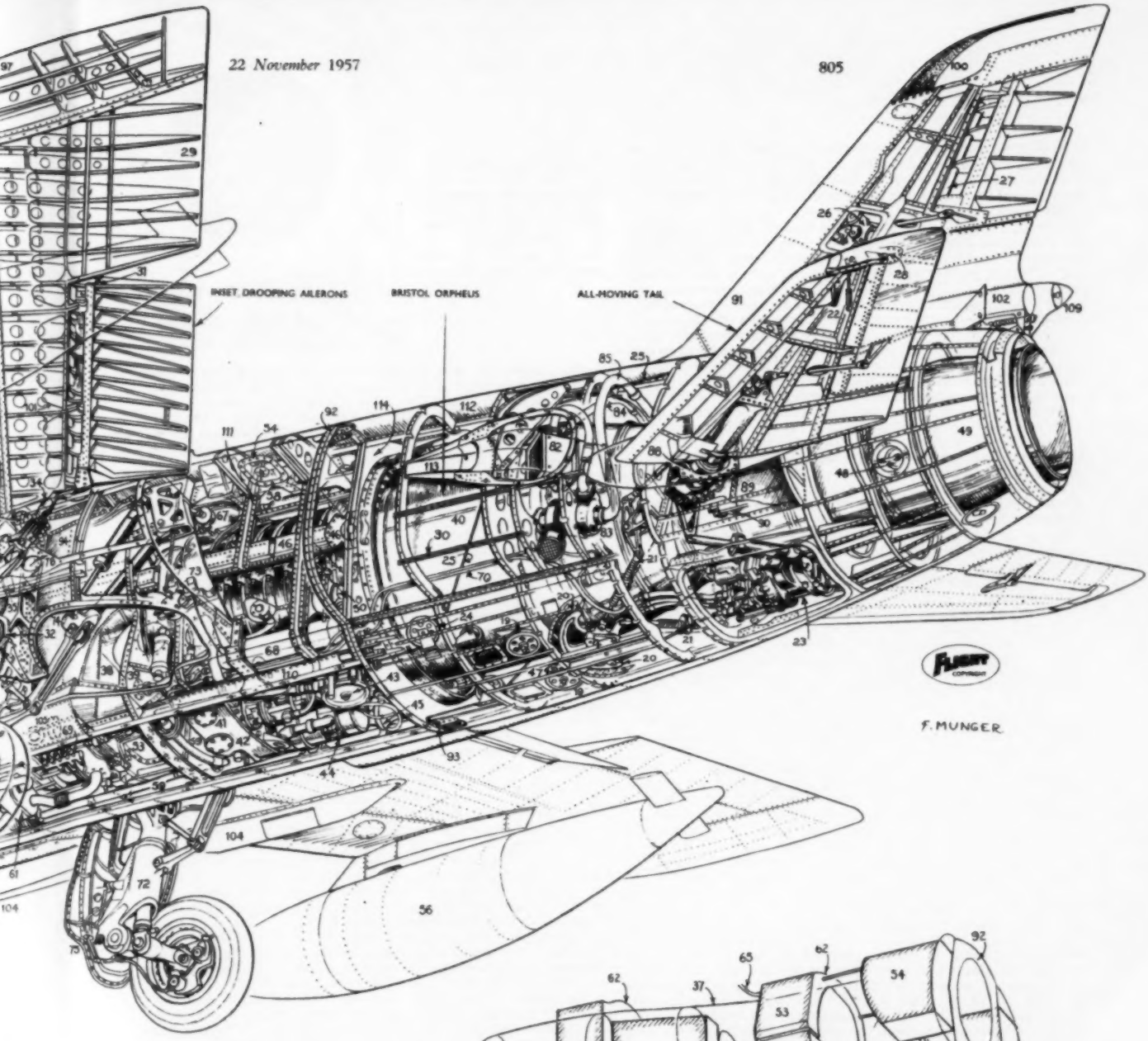
The ducts pass through the shear wall in the region of frames

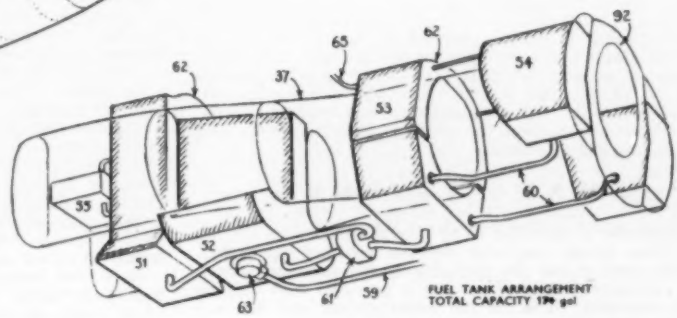
(*Continued on page 806, after double-page drawing of Gnat*)

GNAT Mk I . . .



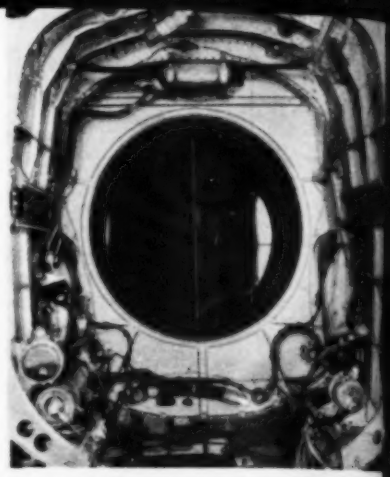
1 Dielectric nose cap
2 V.H.F. T/R (main, below; standby, above)
3 Upper half opens upwards on rear edge
4 Cockpit front pressure bulkhead
5 Unpressurized "box" housing electronics and cockpit pressure control
6 S.B.A.C. standard rudder bar, hydraulic toe brakes
7 Folland-Saab lightweight (47 lb) ejector seat
8 Elevator unlock (manual reversion)
9 Brake chute release
10 Canopy jettison
11 Undercarriage lever
12 Canopy lock
13 Control column
14 Gunsight
15 Engine power (gunsight twistgrip, relight, press to transmit buttons)
16 Rear pressure bulkhead
17 Stacked control quadrants (top to bottom: elevator, oval aileron pulley, rudder)
18 Control cables along sides of bay
19 Elevator cable pulleys
20 Elevator quadrant operating power control valve and feel springs or elevators only when unlocked
21 Telescopic control rods compressing feel springs in "power," rigid when locked for manual elevator control
22 Elevator lock, withdrawn when tubes (21) are locked
23 Hobson tailplane power unit. Hydraulic motor driving screw jacks. Electric trim
24 Rudder cable pulleys
25 Rudder cable running round both sides to base of fin
26 Bell crank giving mechanical advantage to rudder control
27 Mass balance
28 Inset hinges on all surfaces
29 Trailing edge wrap-round skin
30 Extruded stringers
31 Pressed channel-section spars
32 Pulley and crank for aileron droop driven by toothed quadrant on top of port leg
33 Pilot's aileron control input
34 Aileron power jack
35 Port side main forging, carrying undercarriage, wing pick-up, gun mounting and aileron controls
36 Forward main frame carrying front wing pick-up, gun front mounting and recoil loads
37 Bifurcated duct between stressed shear walls
38 Duct, end of bifurcation
39 Forward engine bay front bulkhead, also rear wall of tanks 3 and 4
40 Annular combustion chamber
41 Wheelcase
42 Vickers fuel pump
43 Low pressure fuel filter
44 Generator
45 Generator cooling air
46 Engine main bearer (front steady starboard side)
47 Combustion chamber drain
48 Thermocouple
49 Cantilevered tail pipes
50 High energy ignition unit
51 No. 1 tank (54 gal) all tanks bag type
52 No. 2 tank (39 gal)
53 No. 3 and 4 tanks (32 gal)
54 No. 5 and 6 tanks (29 gal)
55 No. 1A tank (20 gal)





FUEL TANK ARRANGEMENT
TOTAL CAPACITY 179 gal

56 Jettisonable fuel tanks (66 gal each) fuel transferred by air pressure
57 Fuel contents gauges give single reading of total
58 Oil tank
59 Fuel supply to engine
60 Transfer pipes
61 Fuel flow proportioner
62 Fillers in No. 1 and No. 3 tanks
63 Booster pump. Anti-G provision
64 Pressurizing air to wing tank
65 Fuel supply from wing tank
66 Electric cable conduit
67 Hydraulic reservoir
68 Hydraulic accumulator (air pressure used for emergency service)
69 Four-position hydraulic selector
70 Hydraulic lines to tailplane power control
71 Accumulator air charging point
72 British Messier undercarriage. Shortening on retraction
73 Mechanically operated up-lock
74 Breaker strut down-lock
75 Doors fixed rigidly to leg. Stressed as airbrakes
76 Aden Mk. 4 30mm cannon
77 Gun blast reducer
78 Case ejection
79 Ammunition tank (115 rounds per gun) serving as empty link container for opposite gun
80 Feed chute
81 Empty link transfer
82 Cabin-air heat exchanger in cooling air duct to tail pipe
83 Cold air unit. Fan exhausting into bay
84 Compressor bleed to heat exchanger
85 From cold air unit via spine to cockpit
86 Oxygen. Two 400-litre bottles
87 Ground power supply
88 Tailplane hinge housing
89 Vertical diaphragm supporting inner end of (88)
90 Electric trim limit switches
91 Fin integral with fuselage
92 Fuselage-break joint. Eight-bolt fixing
93 Fuselage-break attachment bolt
94 Stressed vertical shear walls running from cockpit to break joint
95 Boundary layer bleed, top and bottom
96 Pylon mountings
97 Detachable tip
98 Frame supporting platform for 24-volt battery. Electrical equipment stowed around bay
99 I.F.F. aerial
100 V.H.F. T/R aerial
101 Reduced doubler skin from rear spar to these limits
102 Stowage for 5ft dia brake chute
103 Cine camera
104 Pressure head (with certain underwing stores readings taken from vents in nose)
105 Pulleys transmitting port side aileron droops to starboard
106 Oval pulleys to give non-linear aileron response
107 Main wing pick-up bolt
108 Bolt-on points, stringers to centre box
109 Lights
110 Main longerons
111 Stiffeners on vertical shear wall
112 Mono-cocque rear fuselage
113 Cold air intake to heat exchanger and jet pipe
114 Stainless steel fire wall



The fuselage, looking forward from frame 22A. The flanks are the magnesium shear walls and the end of the intake duct is at frame 18. Accessories are distributed near the stressed panel in the under-fuselage.

11 and 12; and the latter frame passes shear loads across them. It also holds the front wing attachments and the forward mounting of the heavy, built-up beam which supports the front of the gun and its recoil loads on each side. Frame 12 further separates Nos. 1 and 2 tanks.

Between frames 12 and 16 the main fuselage loads are taken by the magnesium shear walls which here form the inner wall of the gun bay. The two Aden guns are mounted almost on their backs and supported by the beams from frame 12 and on the two forgings on frame 16. The outer skin is here entirely unstressed and forms a panel which uncovers the entire gun bay. Immediately beneath the guns are the ammunition cans, each of which holds 115 rounds of 30 mm ammunition, disposed athwartships. Each ammunition belt therefore emerges over the forward lip of its can, turns down and runs through a flat duct underneath the can before turning sideways and upwards into the breach. Expended cases are thrown through tubes and emerge high up in the sides of the fuselage so as to pass over the top of the tailplane. These tubes have recently been raised since it was found that some cases were striking the tailplane. Expended links are passed down chutes outside the can, across the fuselage and into the space being cleared in the opposite can as fresh rounds feed to the gun. A canvas separator prevents confusion. Earlier, links were collected in the fuselage, but the aileron-drooping linkage has since cut across the available space here.

Frame 16 carries the main wing pick-ups, the main undercarriage, the rear mountings of the guns, and the aileron actuators and drooping gear; and its reinforced web locates the intake duct and forms the front wall of Nos. 3 and 4 tank bays. The first four of these tasks are performed on each side by large die forgings, bolted to the frame web out-board of the shear wall. They can truly be said to earn their keep in the best Gnat manner.

Frame 18 divides Nos. 3 and 4 tank bays from the engine bay which is flanked by the shear walls, mainwheel wells and Nos. 5 and 6 tanks. The underside is a stressed panel giving access to control runs and engine accessories. Frame 19 is sloped back past the wheel wells and joins frame 20. Castings bolted to the shear wall just forward of frame 19 provide attachment for the main-wheel jacks and radius rods, the shear walls being dished here to accommodate the wheels.

Light-alloy sheet webs close off the fairings at frame 22A, while frame 22B, which is clamped against it, carries a steel fire wall and is designed to redistribute the shear stresses from the shear wall in the forward fuselage into the outer skin of the tail section.

As stated earlier, fuselage loads are carried across the break between frames 22A and 22B by eight spigots which are bolted into fittings. Special provision is made for achieving a good fit without having to observe too-close jigging tolerances. From this point aft, the fuselage becomes a conventional monococque, with Z-section stringers and light frames.

Frame 26 is inclined rearwards and is integral with the forward spar of the fin. In similar fashion, frame 27 picks up the rear fin spar; and the tailplane pivots are located in boxes formed by both vertical and horizontal webs between the frames. The pivots themselves are magnesium castings in which the ball-bearing housings are slit and clamped by bolts to allow for differential expansion. Both fin and horizontal tail units are of conventional built-up construction, all moving surfaces having inset hinges and lead mass balances.

GNAT SYSTEMS

THE simplicity of the Gnat flying control system is in keeping with Petter design traditions, with the undercarriage providing airbrake surfaces and also operating the flap-drooping system. In fact, a complete range of services is provided with only six hydraulic actuators, three for the undercarriage, one for each aileron and a twin unit for the horizontal tail.

The rudder is directly mechanically operated through a cable transmission driven by a short push-rod from the standard S.B.A.C. rudder pedals and ending with a push-rod linkage inside the fin. The pedals are adjustable for reach. For control on the ground, individual toe pedals directly operate each mainwheel disc brake hydraulically. Neither Maxaret nor power assistance is considered necessary. The nosewheel is self-centering, and is not steerable. In order to reduce rudder cable travel, and thereby the required size of the quadrant working the push-rods in the fin, double pulley units providing a 2:1 reduction are mounted just forward of this point. Spring centering with a positive indication of central position is provided for comfort and to allow "feet off" flying. It is foreseen that a viscous yaw-damper cylinder will be interposed in the linkage in the fin.

For aileron operation the control column is articulated just below the hand grip, the pivot carrying a pulley wheel which engages the cable running down to the base of the column and thence rearwards to a further pulley lying flat between tailplane and rudder quadrants. This pulley in turn carries a cable linkage to two sprockets engaging a section of chain in the main aileron cable loop. The valves of the Lockheed aileron Servodynes are controlled by push-rods operated from the centre of a beam, one end of which is moved from the butterfly segments carrying the main aileron cable loop. The other end of the beam is held by a link mounted, to port, on a wheel directly geared to the main undercarriage pivot-pin. Thus the rotation of the undercarriage leg alters the datum on which the aileron operating rod moves. The link is so mounted on the geared wheel that the rotation of the undercarriage from the "up" to the "airbrake" position imparts a negligible droop to the aileron—something less than $\frac{1}{4}$ deg. A similar datum-varying arrangement is incorporated on the starboard side and operated by a cable linkage from the port side. Formerly each main-wheel leg drove its own aileron-drooping linkage, but it was found that, during lowering, one leg was slightly ahead of the other and a momentary asymmetric droop resulted.

In order to reduce aileron response near the neutral position, the three pulleys in the aileron circuit are oval. Feel is provided by a plain spring in the control column. In case of failure of the hydraulic supply to the aileron Servodynes the existing linkage between stick and valves has been made strong enough to accept the full mechanical loads for manual operation. The Servodyne body, carrying the valve, operates the aileron; and in manual control a slight backlash due to valve movement occurs. It is, however, very slight and allows automatic and immediate manual reversion.

Total undercarriage-leg travel is 125 deg; and the airbrake position is reached after 20 deg of main leg and 50 deg of nose leg travel. The normal range of aileron movement is -14 deg to $+12.5$ deg but, with the undercarriage fully down, the ailerons are drooped 22 deg and their travel is increased from -21.5 to $+18$ deg. The Servodynes themselves accommodate these travels with a total movement of only 3.2in.

The latest Gnat horizontal tail control retains an elevator mounted on a moving tailplane, but for all normal flying the elevator is locked to the tailplane by a bolt in the horn balance the two then acting as a one-piece slab unit. Normal operation is as follows: Fore and aft movement of the stick operates a butterfly segment carrying the cable loop running in the under-fuselage to a quadrant on the rear-fuselage floor. This quadrant carries a specially cut cam which imparts non-linear response to a push-rod working the hydraulic valve of the Hobson unit. The cam has been so profiled that tail response to stick movement is reduced near the neutral position. Thus, at very high speeds when small angular movements are required, low tail-plane response makes the system less sensitive. Response is greatly increased over the higher stick deflections.

As is well known, the Hobson unit consists of a hydraulic motor, controlled from the cockpit, driving twin screw-jacks which rotate the tailplane pivot through an epicyclic reduction gear in which the motor shaft drives the sun wheel and the planet wheels drive the jacks. Trim is provided by an electric motor controlled from a switch on the control-column grip, arranged to drive the annulus of the epicyclic gear. The trim motor can thus move the tailplane through its full range of $-16\frac{1}{2}$ deg to $+2\frac{1}{4}$ deg without affecting the stick datum.

The tailplane quadrant in the rear fuselage can also operate a push-rod linkage to each elevator, but for all normal flying the elevators are locked by bolts to the tailplane. The push-rods are telescopic in this condition and the piston section of each moves two springs housed on the cylinder section to provide spring feel for the horizontal tail system. The springs on each side are pre-loaded to give a stick load over the central 15 deg of stick movement twice that over the rest of the range. Centering cams at the base of the stick positively show the neutral position. Peak push-force is about 25 lb and the peak pull force slightly higher. This varying stick rate causes a relatively high force over the small

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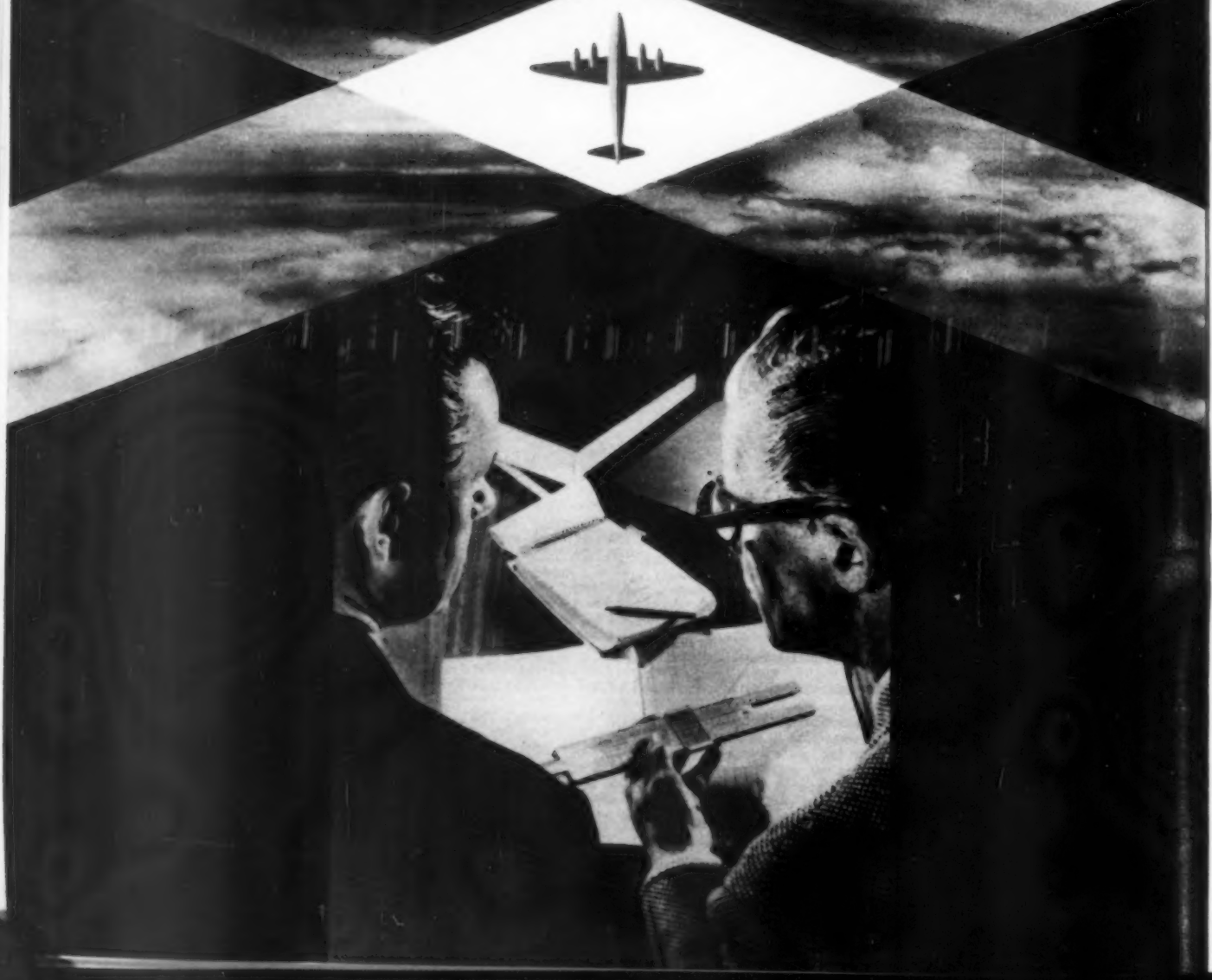


deflection angles generally used at high subsonic speeds with little increase in force at the larger deflections used at speeds above Mach 1 and on the approach. The Hobson unit can take a maximum load of 750 lb, and can achieve a rate of 1.5 to 2 in/sec with a 500 lb end-load. The electric trim motor, at 24 V, can exert a maximum of 400 lb per jack.

In case of hydraulic supply failure, a warning light indicates loss of pressure. Though loss of tailplane response follows, the hydraulic accumulator will still provide sufficient pressure for a 12 deg movement of the tailplane, this being sufficient to restore the tailplane to a suitable angle for effective manual control. In the meantime, the electric trim-motor remains available to change tailplane angle at one-tenth of the speed provided by the hydraulic motor. To continue in manual control the pilot can pull a lever on the left side of the cockpit in order to disengage the elevator locks through a Teleflex linkage. This also locks the telescopic rods to close the mechanical control-loop. From this moment the pilot has direct mechanical control of the elevators with normal aerodynamic feel. Stick loads are then fairly heavy.

Compared with those of other aircraft in the same operational category, the hydraulic system is delightfully simple. As already described, there are only six hydraulic jacks to be operated; and three of these are controlled by a single selector-valve. Four of the jacks are close to the engine-driven pump and many of the system components. The whole system holds nine pints of D.T.D. 585 fluid, some 159 cu in of which are in the header tank when the single pressure-accumulator is uncharged. In this condition, the accumulator is pressurized with air at 1,500 lb/sq in; and this air can be used for emergency undercarriage lowering. Accumulator pressure is also sensed on the air side and displayed on a gauge in the cockpit reading from 0 to 3,000 lb/sq in. The accumulator, made by Lockheed, holds air in an annulus so that the piston travels the full length of the body, the overall size of the unit thus being kept to a minimum. Mounted on the lower port side of the forward engine bay, the accumulator holds a maximum of 40 cu in of fluid.

Hydraulic pressure is built up by a standard Lockheed Mk 9 engine-driven pump. Operating pressure is 3,000 lb/sq in and maximum delivery is 900 cu in/min. A relief valve opens at 3,500 lb/sq in; and a cut-out valve returns pump delivery to the header tank when the accumulator reaches 3,000 lb/sq in. It cuts in again at 2,500 lb/sq in.

Main delivery pressure is branched three ways, to the undercarriage, ailerons and Hobson unit, but a pressure-maintaining valve is interposed upstream of the aileron and undercarriage supplies so that, if line pressure drops below 2,000 lb/sq in, these two circuits are cut out and manual reversion and emergency extension respectively have to be used. In this way the remainder of a failing pressure supply is reserved for the tail control exclusively. A pressure switch downstream of the maintaining valve lights a warning lamp in the cockpit when pressure drops below 1,600 lb/sq in, which occurs as soon as the maintaining valve closes. Normal working is re-established if the pressure once again rises to 2,400 lb/sq in.

The undercarriage is controlled by a single selector valve, located under the tank floor just forward of the engine bay and operated by cable from a single cockpit-lever marked "up", "airbrake", "down" and "emergency". In the up and down positions fluid flow is passed directly to the appropriate side of the undercarriage jacks. In the airbrake position the flow is passed from the jacks through sequence valves operated by cams on the mainwheel legs and nosewheel jack so that flow is cut off when the airbrake position is reached. From the up position, the nosewheel reaches the airbrake setting in one second while the mainwheels take 0.4 sec. The full extension cycle takes about nine seconds.

The Gnat carries a complete air-conditioning system, including pressurization with temperature-controlled air, separate hot air demisting for windscreen and canopy, provision for g-suit and ventilated suit and radar cooling. Charge air is taken from two engine bleeds just aft of the Orpheus compressor section. At full power at sea level, bleed temperature and pressure are about 450 deg C and 94 lb/sq in; and a cold air unit and ram-air heat exchanger can reduce this to about 0 deg C. Pressurization is, of course, controlled by throttling the outflow of conditioning air from the sealed cockpit. The cabin remains unpressurized from sea level to 15,000ft, after which the pressure builds up to a differential of 3½ lb/sq in at 40,000ft and above. Separate warning devices come into operation if cabin pressure drops more than 0.5 lb/sq in below the required level and if the dangerous cabin altitude of 42,000ft is reached.

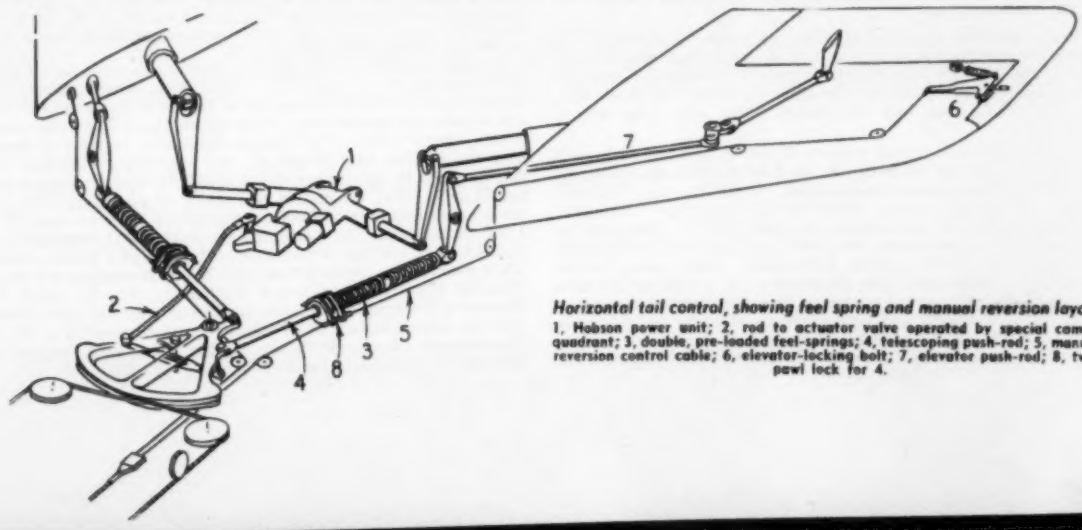
Of the two compressor-bleeds which serve the cabin, one is led direct, through appropriate reducing and non-return valves, to the windscreen demisting pipe, the flow being controlled manually by an on/off valve. A branch from this also supplies the Dunlop g-suit valve; and a further branch is taken through a differential-pressure control valve to the canopy seal, keeping this at 3 lb/sq in above cabin pressure whenever the canopy is shut. Either normal or emergency canopy unlocking devices operate a sequence valve to deflate the seal.

The other compressor bleed is led straight to a Normalair double-butterfly valve controlled by Teleflex cable from the cockpit. Through this unit all the hot charge-air can be directed straight into the spray ring round the base of the canopy and into a spray pipe over the pilot's feet. Alternatively all the charge air can be directed through the Marston ram-air heat exchanger mounted in the intake which passes ram air into the cooling shroud round the hot part of the Orpheus. At full speed, this exchanger reduces charge-air temperature from 240 deg C to 168 deg C. The air then flows into a small Normalair brake turbine cold-air unit mounted just aft of the heat exchanger. It is a 12.4 lb/min unit and can reduce charge air temperature to −14.7 deg C. In-between temperatures can be obtained by setting the double-butterfly valve to appropriate intermediate positions. A special tropical cold-air unit may be fitted.

The air space between the thin outer and thick inner layers of the Triplex glass windscreen is maintained at ambient pressure by a special bleed to atmosphere fitted with a silica-gel desiccant cartridge. A muff round the pressurization valve on the front cabin bulkhead collects dumped cool air and passes it to the radar boxes in the nose bay at slightly above ambient pressure.

The Gnat carries no fewer than seven internal bag tanks for fuel within the fuselage giving a total capacity of 174 gal. They are numbered 1 to 6, an additional 20-gal unit, called 1A, having been added in the bottom of the equipment bay behind the cockpit. Their layout is shown on page 805. Nos. 1, 2, 3, 4, 5 and 6 tanks hold respectively 54, 39, 18, 14, 14½ and 14½ gal. With the two 66-gal wing tanks total fuel capacity is 306 gal. No. 2 tank is the master unit and holds the main refuelling vent with its float valve and the S.P.E. booster pump with its negative-g provisions. From here fuel is led *via* the low-pressure cock to the engine. The two tanks forward of this and the four tanks aft of it form two fuel blocks, total contents being measured by Smiths Waymouth capacitance units in Nos. 1, 2 and 6 tanks and totalized on a single gauge, reading in pounds, in the cockpit.

Tank pressurization and fuel transfer are by engine-bled air (from a third bleed) which is passed through a Hymatic pressure-reducing and vent valve direct to the wing tank pylons. Here it is either led into the wing tanks or straight back through the wing-tank feed lines to the fuselage tanks, according to whether drop tanks are in place or not. The starboard wing tank feeds into No. 1 tank while the port fuel is passed to No. 3 tank thus preserving the c.g. Special Exactor couplings at the wing pylons ensure that air pressure is passed directly back to the fuselage



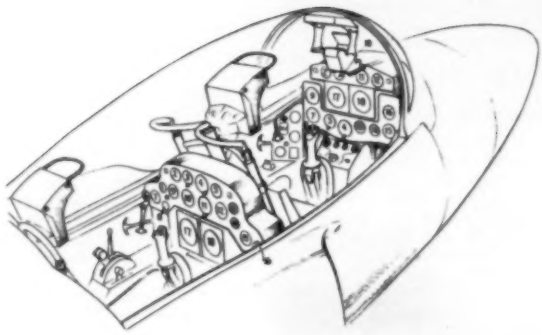
Horizontal tail control, showing feel spring and manual reversion layout.
1, Hobson power unit; 2, rod to actuator valve operated by special cam on quadrant; 3, double, pre-loaded feel-springs; 4, telescoping push-rod; 5, manual-reversion control cable; 6, elevator-locking bolt; 7, elevator push-rod; 8, twin-pawl lock for 4.

tanks as soon as the wing tanks are jettisoned, or when they are not fitted at all. This air pressure transfers fuel in the two groups of fuselage tanks and thence, through a Gloster mechanical fuel-flow proportioner, into No. 2 tank. Special Hymatic two-way vent valves from Nos. 1 and 3 tanks prevent excessive differential pressures building up; and a ball valve in the main vent from No. 2 tank closes automatically during negative-g conditions. The negative-g trap round the booster pump simply causes the pump to draw from the middle of the tank during inverted flight. No. 2 tank is kept full until all fuel is exhausted. Warning lights in the cockpit indicate a drop in fuel pressure or a reduction in fuel flow.

Although electrically as simple as it is in other respects, the Gnat provides all the current supplies needed by radio, radar and ancillary services. A 3.5 kW Rotax 24 V generator is driven by the engine and supplies a Varley 25 A/hr lead acid accumulator mounted in the nosewheel bay. A Varley 4 A/hr battery is stowed in the nose compartment and supplies emergency power to operate the single-channel standby V.H.F. radio and the turn-and-slip indicator. The main battery has its two 12 V units mounted end-to-end, to fit its stowage alongside the nosewheel. Stabilized A.C. supplies are produced by a Rotax Type 100A invertor in the aft equipment bay and a B.T.H. Type 200 invertor, serving radar equipment, in the nose compartment.

The Gnat carries the full complement of night-flying lighting and standard electric gyro instruments for blind flight. Provision is made for a Telebrief land-line installation; and Ferranti have produced a special lightweight gun-sight. Follands have exhibited a radar ranging installation. An I.F.F. beacon can be carried; and the new Marconi AD.722 lightweight A.D.F. can be installed in the rear equipment bay. In addition to the single-channel standby V.H.F. radio, the Standard Telephones and Cables S.T.R.9 V.H.F. radio with either 10 or 44 channels is carried in the nose compartment. The fin-tip aerial can handle frequencies between 115 and 145 Mc/s.

The Bristol Orpheus is a particularly tight fit in the Gnat fuselage and every inch of clearance is carefully preserved. The fit is indeed so close that the complete filler neck on the oil tank has to be removed before the engine can be inserted into the fuselage. After the mountings are secured the filler neck and its cap are inserted through the appropriate hole under the spine.



Gnat Trainer cockpit, equipped to the very latest standards.
1, undercarriage indicator; 2, r.p.m.; 3, standby altimeter; 4, standby direction indicator; 5, trim; 6, emergency trim; 7, standby attitude indicator; 8, flap; 9, vertical speed indicator; 10, A.S.I.; 11, altimeter; 12, Machmeter; 13, oxygen contents; 14, jet pipe temperature; 15, fuel contents; 16, clock; 17 and 18, attitude indicator and navigation display, both part of the Flight Data System.

The engine is held on its two main trunnions in ball and socket mountings at frame 22A. A single steadying link just aft of the intake ring on the starboard side, picks up a pip pin in an extension of frame 20 and serves to steady and locate the engine. The whole combustion, turbine and tail-pipe sections are cantilevered. Installation and removal are carried out with the aid of a trolley. The lip of the engine intake carries a rubber ring which forms a seal against the end of the intake duct at frame 18; and a sprung wire carrying a steel strip with an asbestos gasket performs a similar function at the inner edge of the fire wall at frame 22B. Compressor and combustion section are thus isolated. Graviner Firewire is led all round the engine installation and provides light indication of fire. There is no extinguisher system.

The space round the engine aft of the fire wall is ventilated; and the double skin of the exhaust shroud itself is cooled by ram-air collected by an intake on the port side of the fuselage. Hydraulic pump, fuel pump and generator are the only engine-driven accessories; and the hydraulic accumulator, two booster coils, the hydraulic header tank and sundry valves and piping are located in the forward bay. Access to a number of these units is through specially arranged panels in the mainwheel wells. Engine-driven accessories, flying-control cables and piping can be reached by removing the panel under the engine compartment. C.M.L.

DR. LACHMANN, NATO AND RUSSIA

A LECTURE delivered before the Royal United Service Institution in London on November 13 by Dr. G. V. Lachmann, F.R.Ae.S. (director, scientific research, Handley Page, Ltd.) under the title *The Designer's Dilemma*, gave, *inter alia*, these conclusions:—

Recession in the field of conventional military aviation, coupled with greater austerity of programming, is not restricted to this country. The symptoms are becoming very noticeable also in the U.S.A. The British aircraft industry is already re-orientating and adapting itself to a new outlook of rationalism with the resilience acquired in the course of its long existence. This resilience has carried the industry through difficult periods in the past. The fact that the Government will demand in the future a co-operation of two or more firms in tendering for a new contract confirms the industry's own tendency towards consolidation. Pooled technical resources, design capacity and production facilities will speed delivery. Whilst there is still some room for the development of manned service aircraft for tactical purposes and for the needs of other NATO countries such as West Germany, the signposts of future development point decidedly towards the field of transportation.

"I have tried to indicate," said Dr. Lachmann, "that there is no ground for apprehension that a decline of the aircraft industry may come about through lack of work or potential targets. Some real belt-tightening is inevitable though. A serious decline may, however, result from lack of rational policy and from lack of stability."

The purely civil-aviation aspects of the lecture are dealt with on page 795. On the military side Dr. Lachmann made some particularly interesting observations under the sub-heading "Manned Aircraft for Tactical Use in Other NATO Countries." He said: "In contrast to the programme of other NATO countries the British White Paper almost completely excludes the development of manned aircraft for tactical application. Since many British aircraft companies will find themselves in a difficult position because of cancellations of contracts, they might find a temporary outlet for their design and production capacity by satisfying the needs of other NATO countries who do not yet subscribe to the White Paper philosophy. A potential market exists, in my opinion, in Germany. The German aircraft industry is not yet sufficiently resurrected and a very powerful bureaucracy hampers technical initiative. With the present set-up it would seem impossible for Germany to develop the tactical aircraft needed within the next three or four years. The German industry, therefore, looks for technical partners abroad and would finance suitable development in other countries so that it could build aircraft later under licence. Close collaboration exists already with France and Italy and recently an Anglo-German committee has been formed to stimulate co-operation in the field of military aviation.

"The Germans have expressed their views on future requirements for their air force, through Lt. General Kammhuber and Lt. General Galland. They are based on their assessment of the aircraft which will equip the Russian tactical air force in 1960. Dr. Lachmann then gave the following data:—

Mig-19 (Farmer): A fighter having 17,940 lb thrust, of 34.8ft span, 22,000 lb gross weight, and a speed of 776 kt at 36,000ft. Mig-21 (Faceplate): A fighter with 20,000 lb thrust, 49.5ft, 22,900 lb, 1,020 kt at 36,000ft. Blowlamp: A tactical bomber with 20,000 lb thrust, 65.6ft, 79,000 lb, 575 kt at 40,000ft, and 1,000 miles range. Suchoy 3 (?): 7,900 lb thrust, 25.4ft, 12,750 lb, 850 kt at 33,000, 960 miles, Stormovik: A ground-attack aircraft, 8,000 lb thrust, 41.4ft, 26,400 lb, 512 kt, 672 miles; Antonov An-8 (Camp); Light transport, 10,200 lb thrust, 100ft, 88,200 lb, 302 kt, 1,725 miles.

The lecturer added: "In order to face these aircraft the Germans have expressed the need for a supersonic strike-fighter (light fighter bomber) which can operate at heights of 24,000ft to 33,000ft and which can take off from short aerodromes. They also want a heavy fighter-bomber and a home intercepter capable of dealing with the Russian Mig-19 and 21, and "Blowlamp" fighters. For this fighter a Mach number of 2.5 is stipulated and an operational height of 75,000ft. It should be capable of operating from grass surfaces, and its take-off distance should not be more than 550 to 1,100 yards, since the Germans anticipate total destruction by missiles of all military aerodromes in the case of a Russian attack. They also need a night fighter [*sic*] of Mach number 1.5 to 1.6. Potential types are the French Trident II (M=2), which it is claimed will take off from grass surfaces of only 550 yards length, and the Saunders-Roe SR.53 which was demonstrated at the last Farnborough Show. Both the British and French aircraft are fitted with a mixed powerplant."

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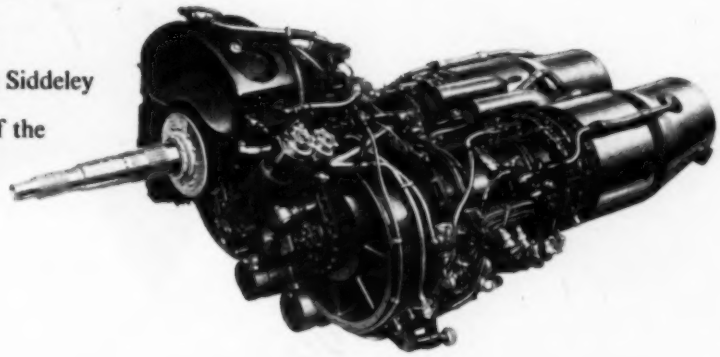

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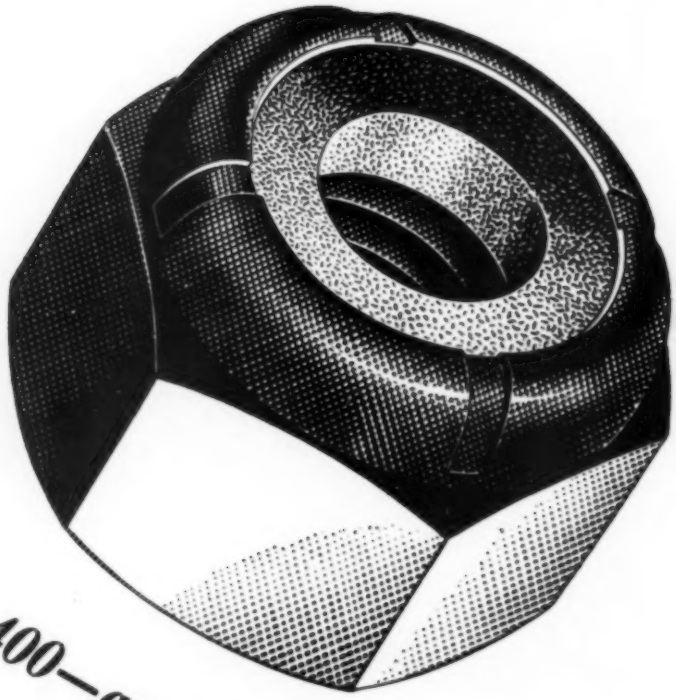

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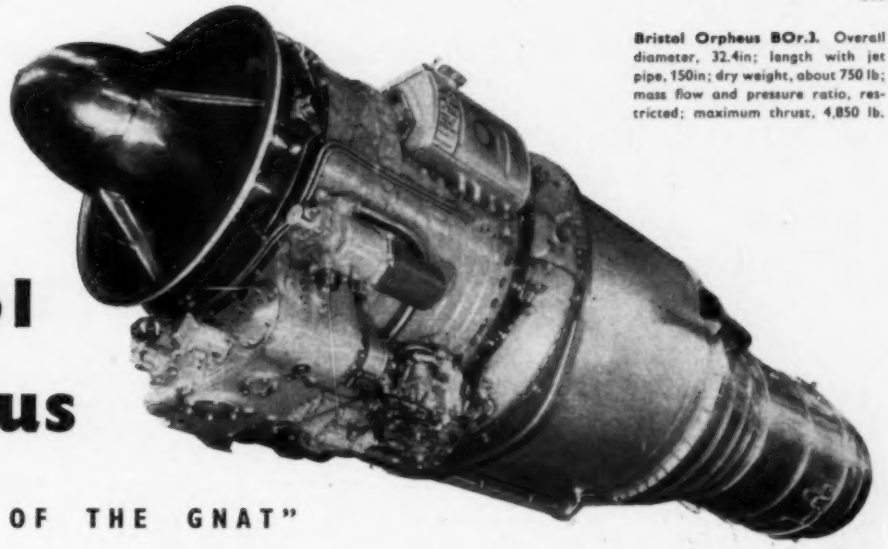


Bristol Orpheus BOr.3. Overall diameter, 32.4in; length with jet pipe, 150in; dry weight, about 750 lb; mass flow and pressure ratio, restricted; maximum thrust, 4,850 lb.

Bristol Orpheus

"THE HEART OF THE GNAT"

FEW aero engines can claim a success record comparable with that already established by the Bristol Orpheus. Within three years of its first run it has been selected as the powerplant of fourteen new types of aircraft, thirteen of which are of foreign design. It is already flying in five different types of aeroplane and has performed superbly during an exceptionally rapid and trouble-free development.

It is now possible to publish a detailed description of all but the most advanced types of Orpheus, and to reveal the singularly ingenious features which make this engine so simple to construct and maintain. At the end of this account is appended the genesis of the design and an account of its current progress and future prospects.

The Orpheus is a single-spool engine, having a single-stage turbine driving a seven-stage axial compressor. The compressor and turbine are coupled by a shaft to form a single main rotating assembly, which is mounted in only two bearings, a ball thrust bearing forward of the compressor and a roller bearing behind the turbine. The following description primarily concerns the BOr.3, although the BOr.1, 2 and 4 are very similar.

The front bearing is mounted in a light-alloy intake casing, the inner structure of which is joined to the outer circumference by four hollow radial vanes. These vanes mate with those of the air intake duct, which is likewise fabricated from light alloy and forms the front extremity of the engine. This duct incorporates a centrally-disposed bullet, which in some types of Orpheus serves as a fairing for a cartridge starter bolted to the front face of the intake casing. The Gnat's BOr.2 has a pneumatic starter mounted in the same position, the fairing being slightly reduced in size. The upper and lower radial vanes of the duct carry pitot heads which measure the air pressure for the barometric pressure control. Also cast integral with the intake casing is the accessory gearbox, driven from the main shaft by means of a bevel drive passing through the lower vertical vane. On the rear face of the gear chamber are mounted the generator on the starboard side, a Lucas swash-plate fuel pump in the centre and a hydraulic pump on the port side. The front face supports the main oil pump, the tachometer generator and, in some installations, a second hydraulic pump.

At its rear end the intake casing houses the entry guide vane assembly. Bolted to the rear of the intake casing are the light-alloy upper and lower compressor casings which carry six rows of stator blades. These half casings are secured at their rear ends to the delivery casing of the compressor, and it is a feature of the design that one of the half casings can be removed without dismantling the remainder of the engine, in order to permit inspection of the complete rotor, which may be turned over by hand. Each of the half casings has six dovetail grooves in which the stator blades are fitted, the latter being retained by simple spring-clips at each joint flange. An external tapping on the lower right-hand side of the casing provides a supply of cooling air for the turbine bearing.

Compressor rotor blades are held by fir-tree roots in discs which, together with intermediate spacer rings, are secured by through-bolts. A stub-shaft bolted to the first-stage disc supports the rotor in the forward thrust-bearing. Bolted to the rearmost compressor disc is the turbine shaft, which is of large diameter and is secured at its downstream end to the turbine disc. The latter also has a stubshaft, attached to its downstream face, which rides in the rear roller bearing.

Surrounding the cannular combustion system is a cylindrical outer casing, bolted to the compressor-delivery casing at the front and carrying the exhaust-cone assembly at the rear. Within are seven flame tubes, and the inner boundary of the pressure space is formed by an inner casing bolted at its front end to the inner section of the compressor-delivery casing and at its rear end engaging the inner face of the turbine-stator segments by means of a piston-type sealing ring. The seven burners are supported in the delivery casing, the inner and outer parts of which are interconnected by integral radial struts. Each flame tube is located at its forward end on its corresponding burner, and is allowed a limited axial float. At the rear, each flame tube changes in section from circular to segmental to form a turbine-entry duct, within which is contained a section of the turbine stator. Each of the seven stator segments has nine hollow blades, and is bolted to the adjacent segments to form a continuous ring. Igniter plugs are provided in Nos. 4 and 7 flame tubes, the flame spreading in the usual way through interconnectors.

There are 125 blades on the turbine rotor, each of impulse section at the root with increasing reaction towards the tip. The blades are mounted in the rim of the disc by means of fir-tree root fixings, located axially by means of a dowel pin driven through a slot to engage a hole in the root of the blade.

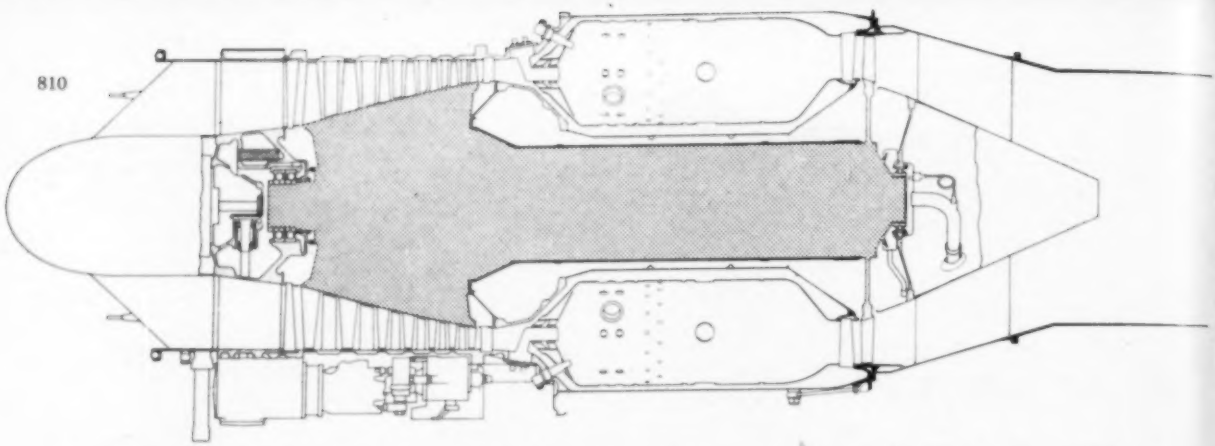
As mentioned above, the exhaust-cone assembly supports the rear bearing for the main rotor. The assembly comprises an outer casing from which the inner bullet is carried by means of eight radial vanes; the bullet, which forms a fairing for the downstream face of the turbine, is of truncated form and extends rearwards beyond the rear flange of the outer casing. The rear-bearing support diaphragm is mounted within the front end of this member, bearing-cooling air being supplied through a pipe passing through one of the radial vanes.

The jet pipe, which is secured by a flange on the exhaust-cone outer casing, carries thermocouple bosses for the measurement of j.p.t., and both the jet pipe and exhaust cone are surrounded by a Refrasil heat-insulating blanket. In addition, there is a light-alloy jet-pipe shroud, which is secured to the combustion-chamber outer casing and surrounds the exhaust cone and jet pipe, providing a cooling air space between the two. The shroud has a stainless-steel inducer riveted to its rear end, so that the jet gases induce the flow of cooling air.

Detail design of the Orpheus in its present form began in December 1953, and progress was extremely rapid from the outset. The first material was ordered early in 1954, and all the detail drawings had been issued to the shops by the end of June of that year. Manufacturing progress also went ahead with great speed —largely as a result of the simplicity of the design—and the first engine was assembled and run on the test bench by December. The speed with which the design was completed was due in no small measure to the increasing body of experience on gas-turbine engines, which enabled the design team* accurately to forecast the performance. Moreover, the Engine Division of the Bristol Aeroplane Co. (as it then was) had gained much useful knowledge of the structural design of lightweight turbojets before the Orpheus project began.

[*contd. overleaf*

**Dr. S. G. Hooker, chief engineer of Bristol Aero-Engines, directed the work of a design team under Mr. B. S. Massey and a development team under Mr. John Dale.*



A longitudinal section of a typical Orpheus, with detail of the construction of the main rotating assembly masked for security reasons.

BRISTOL ORPHEUS . . .

Work on such units started in 1950, when the company began the design of a small expendable turbojet designated B.E.17. This engine had a design thrust of 3,000 lb and was of welded steel construction. It was intended for an expendable bomber and a very short life was therefore envisaged. In its original form it had a two-bearing layout, with a six-stage axial compressor and fully annular combustion equipment.

By the beginning of 1952 this had developed into the B.E.22, and radical changes had taken place in the method of construction. The new engine was of light alloy, and a third bearing was incorporated. The compressor comprised eight stages, and the combustion equipment was of cannular form with separate flame tubes. In addition, the design-thrust was increased to 3,750 lb. The B.E.22, which eventually received the name Saturn, was similarly intended primarily for an expendable bomber aircraft, but it was also discussed with Folland Aircraft with a view to installation in that company's projected light fighter. The version for the Gnat would, of course, have been a long-life engine, but it did not get beyond the design stage because priority had to be given to work on the big Olympus engine for the Vulcan bomber. However, Bristol had by this time accumulated a great deal of design thinking on simple lightweight engines.

In order to make the Orpheus available at the earliest possible date for flight in the Gnat (which in the summer of 1954 was flying in prototype form with a lower-powered engine) the Orpheus was submitted for an official 150-hour type test within five months of its first run. This period is certainly exceptional when compared with other turbojets or piston engines. The initial type test was carried out at a rating of 3,285 lb thrust and was successfully completed, enabling a flight engine to be despatched to Folland the following month. On July 18 the Orpheus took the air for the first time—in the Gnat—at the A. and A.E.E. at Boscombe Down.

In the meanwhile, a specification had been issued by SHAPE for a lightweight strike fighter as a result of studies made by the C-in-C. Allied Air Forces Central Europe, Air Chief Marshal Sir Basil Embry. This specification, which called for a small but rugged aircraft for tactical support of ground troops, resulted in a design competition in 1954 to which ten different design projects were put forward. So outstanding was the Orpheus for this purpose that it was specified by nine of the ten projects, and the tenth design included the Orpheus as an alternative powerplant. As a result of the design competition, the proposals put forward by the Bréguet, Dassault and Fiat companies were selected and three prototypes of each were ordered. These were the Bréguet 1001 Taon, the Dassault Etendard VI and the Fiat G91.

Through Lieut-General Ward H. Maris, the United States made it clear that it was prepared to give financial support to the research and development programmes for these aircraft sponsored by SHAPE, in order to meet the need of the NATO countries for a lightweight strike machine. Study of the powerplant field indicated that the Bristol Orpheus was the only suitable engine to meet the requirement, and the development of the engine was therefore also supported, through the Mutual Weapons Development Program. The R. and D. projects on the aircraft and engine have been carried out under contract to the respective governments, a substantial proportion of the costs being reimbursed by the United States.

The Orpheus was intended to be developed to a design thrust of 4,850 lb, and at an early stage in the NATO programme it was decided that the Orpheus must be developed to this figure for installation in the NATO aircraft. An official instruction to proceed with this development was issued in March 1955. Meanwhile, development and bench-testing had continued at an unusually rapid pace, the running being largely based on the official type-test schedule, with the addition of further tests required for the investigation of particular points.

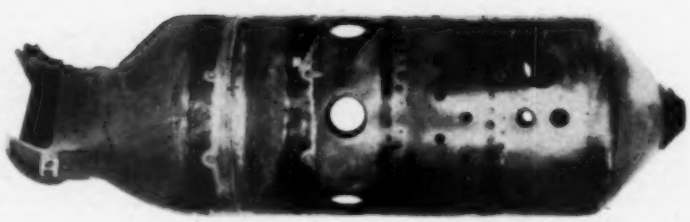
The first version of the Orpheus, known as the BOr.1, completed its official type test at its design rating of 4,050 lb in January 1956, less than 13 months from the first run of the prototype Orpheus.

In the spring of the same year, the 100th flight was carried out by the Gnat, on which all the initial flight experience of the engine was gained. In order to supplement this experience, and to make more detailed measurements of the flight performance of the engine and its accessories, an Orpheus BOr.2 was installed in an Avro Ashton flying test-bed which first flew in April 1956.

Although it was intended that the NATO lightweight strike fighters should be equipped with the 4,850 lb-thrust BOr.3, it was decided that the programme would be accelerated if the initial versions of these aircraft were flown with the lower-powered BOr.1. The Fiat G91, powered by this mark of the Orpheus, took the air for the first time on August 9, 1956, and the Etendard VI, similarly powered, made its first flight early this year.

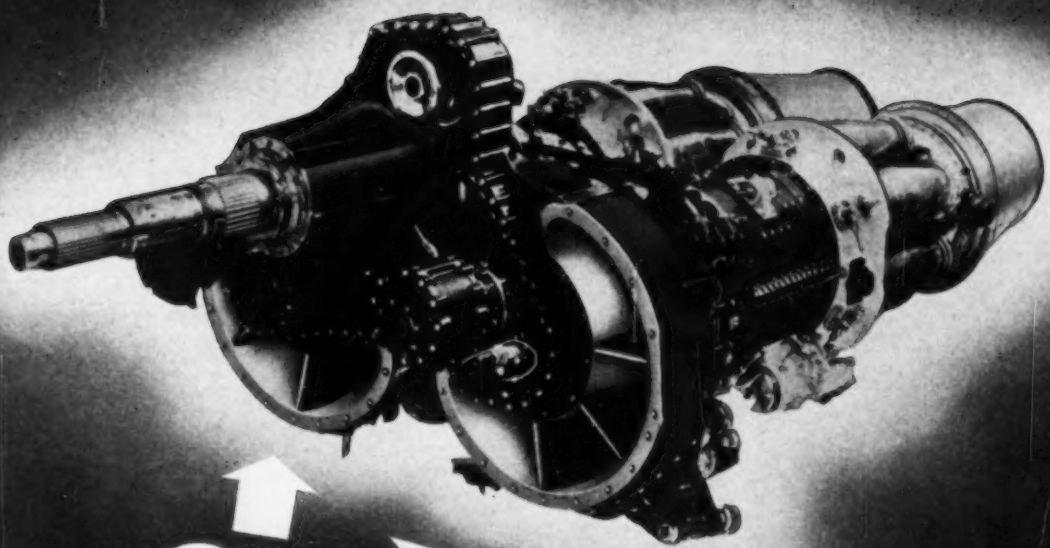
Meanwhile, development of the more powerful engines

The detail above clarifies the attachment of the compressor stator blades in dovetail grooves in each half-casing. Each blade is inserted separately and the assembly in each 180-deg segment is locked by a spring clip on the butt-joint facing.



One of the seven flame tubes, showing the manner in which segments of the turbine nozzle guide vanes are incorporated at the outlet end.

Armstrong Siddeley Double Mamba



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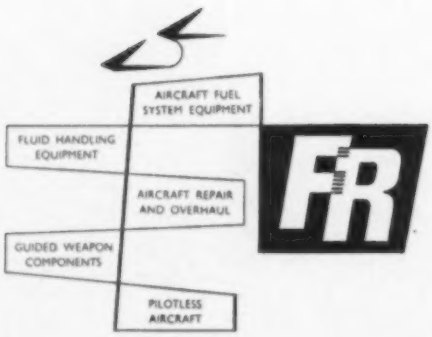

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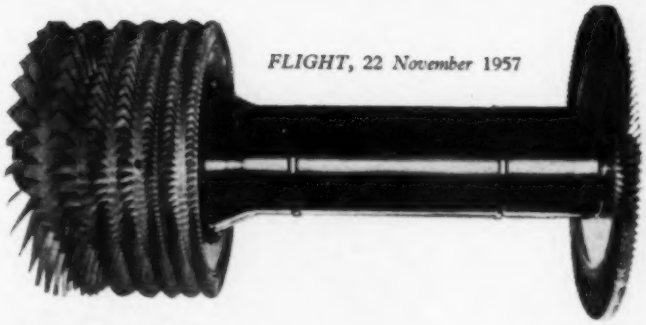

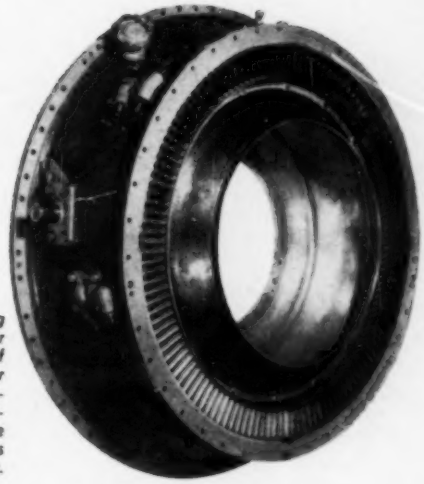

Above, the complete rotating assembly of compressor, tubular shaft and turbine. Backbone of the engine is the compressor delivery casing (right). It incorporates the final row of straightening vanes upstream of the combustion chamber as well as two of the mounting trunnions.

BRISTOL ORPHEUS . . .

proceeded, and the BOr.2, rated at 4,520 lb thrust, completed its official type test in November 1956. The BOr.2, which is used in the Folland Gnat Mk 1, is almost identical with the BOr.3 used in the NATO lightweight strike aircraft, except that, owing to airframe space restrictions, it has a slightly slimmer wheelcase and mounts a smaller fuel pump. The larger wheelcase of the BOr.3 provides drives for the increased-capacity accessories required by the European tactical fighters. As is well known, engine fuel demand falls off with altitude, and above heights of the order of 10,000ft—the exact height depending on forward speed—the performance of the BOr.2 and 3 is identical. The larger fuel pump, however, permits the BOr.3 version to develop somewhat greater thrust at take-off and low altitudes, and so meet the short take-off and low-altitude flight performance requirements of the NATO machines.

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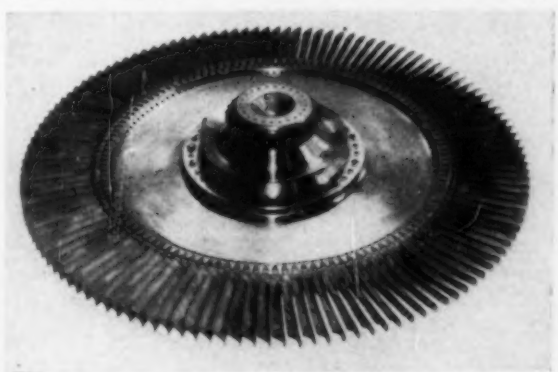

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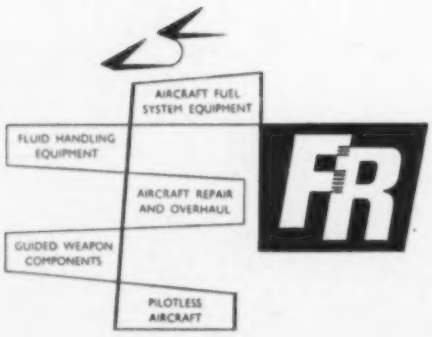

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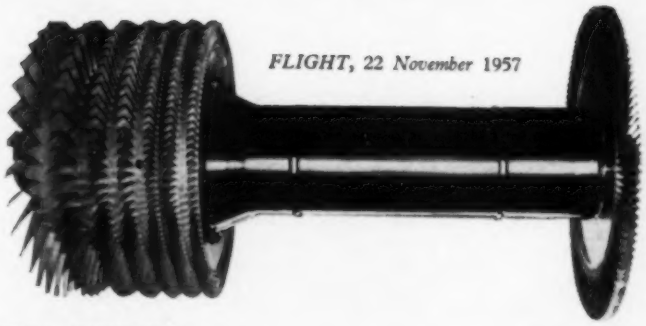

Above, the complete rotating assembly of compressor, tubular shaft and turbine. Backbone of the engine is the compressor delivery casing (right). It incorporates the final row of straightening vanes upstream of the combustion chamber as well as two of the mounting trunnions.

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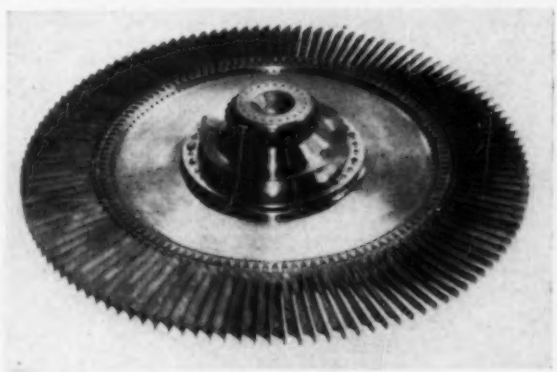

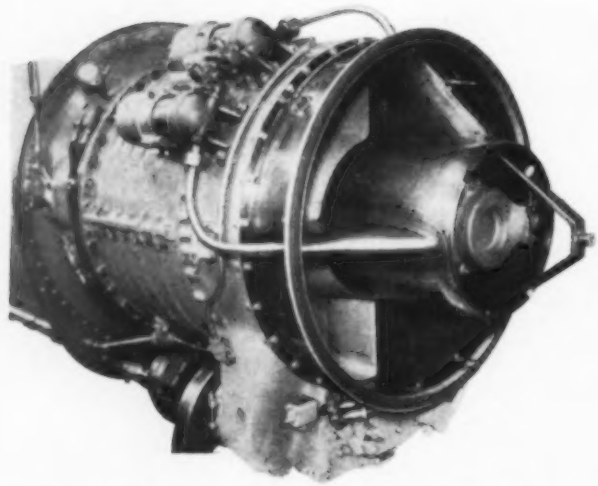

Close-up of a BOr.3 intake, showing twin starter cartridges. On the right is seen the front face of the main intake, showing the wheelcase and compressor intake guide vanes.

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aircraft are foreseen and clearly there are many duties both in the fields of military training and communications, as well as that of civil transport, that this ten-seat swept-wing aircraft could perform exceedingly well.

Another American aeroplane for which the Orpheus has been selected as one of two alternative powerplants is the North American Model 249 jet trainer which at N.A.A.'s Columbus Division is being developed for the U.S. Navy as the T2J. In Japan the Orpheus-powered Fuji TIF-1 trainer is likely to fly in the near future, and the BOr.4 is also scheduled for certain other trainer aircraft including the Fiat G91T, the Gnat Trainer and two-seat versions of the Etendard and Taon. Future Orpheus-powered intercepters include the Folland Gnat Mk 2, the Italian Aerfer Leone and the Spanish Hispano HA.300. Yet another application concerns the Short SB.5 research aircraft, which now has a wing swept at no less than 69 deg. It would also be reasonable to suppose that the Orpheus would be suitable for generating direct lift in VTO applications.

Development of the Orpheus engine was originally intended to be completed when the BOr.3 had been proven at its design rating of 4,850 lb. However, the demand for ever higher aircraft performance has changed the picture, and Bristol Aero-Engines are now developing two advanced versions, designated BOr.11 and BOr.12. The former is rated at 5,760 lb thrust, and has the same diameter as the earlier engines (32.4in) and is slightly longer, at 79.27in. The BOr.12 is rated at 6,810 lb dry thrust, with a take-off figure, using a lightweight form of reheat, of over 8,000 lb. The BOr.12 is also of the same diameter but has a length of 82.7in.

There have been proposals that production versions of the Bréguet Taon, Dassault Etendard VI and Fiat G91 should be equipped with the BOr.12, an engine which has not yet reached the production stage. In addition, two-seater versions of the Taon and Etendard with the BOr.12 are being offered, to combine advanced training with an operational rôle. With this engine, the thrust/weight ratio of the aircraft will be restored to the value corresponding to the gross weight specified in the original NATO specification. Moreover, both the Etendard IV and the Sud Aviation Baroudeur have since been offered with the BOr.12 for NATO purposes.

In addition to the current marks of the engine which are being manufactured in increasing numbers, Bristol Aero-Engines is pinning its faith to these advanced marks for the future. Although in military installations these are likely to be equipped with reheat (in which form there is undoubtedly a big future for the Orpheus) there are perhaps even greater possibilities for civil versions, where the engine's inherent toughness will be translated into the long overhaul life and exceptional reliability for which Bristol engines have been renowned for more than thirty years.

HELICOPTER RADIO INSTALLATIONS

A PLEA addressed to helicopter designers for greater consideration of radio equipment installation problems was the keynote of a discussion held in London by the Helicopter Association on November 8. Five short lectures were delivered under the general title of *Problems Relating to the Installation and Operation of Radio Equipment in Helicopters*. The speakers were Mr. D. W. Griffiths, radio supervisor, Airwork, Ltd.; Mr. M. P. Kitson, Murphy Radio, Ltd.; Mr. R. A. Burberry, Standard Telephones and Cables, Ltd.; Mr. P. P. Creek, Marconi's Wireless Telegraph Co., Ltd.; and Mr. G. Hinchliffe, Decca Navigator Co., Ltd. The chairman was W/C. R. A. C. Brie.

MR. GRIFFITHS began by outlining the general problem and the other four speakers dealt with the detailed aspects of different items of equipment. MR. KITSON described the installation and operation of two-way V.H.F. communications equipment—which was, he said, an essential item for the majority of aircraft. The most significant installation problem to be overcome, apart from the siting of aerials, was that of vibration. Care had to be taken to avoid using flexible mountings having a natural frequency near the cruising r.p.m. of the rotor or its second or third harmonic. Otherwise vibratory oscillations tended to build up and failures be caused.

The difficulties of siting aerials most advantageously were explained by MR. BURBERRY. Because of its relatively large forward structure and low ground-clearance, the single-rotor helicopter was the most difficult to cater for. The best location for an aerial was below the fuselage, where it was unaffected by rotor modulation. If there was insufficient ground clearance forward, it had to be fitted below the tail boom, with consequent shielding by the fuselage in a wide arc ahead of the machine. There was not usually sufficient rotor-blade clearance for a V.H.F. aerial above the fuselage.

This position, however, was favoured by the speaker following, MR. CREEK, for mounting the smaller loop aerials for A.D.F. equipment. The radio compass, said Mr. Creek, had been installed in a number of helicopters and he had carried out a series of tests to determine the most suitable aerial locations on the first installation. Ideally, the loop aerial had to be as far as possible from surface discontinuities and as far as possible from the rotor assembly and sources of electrical noise. It had to be mounted on the fore-and-aft line of the fuselage. The sensing aerial had to be as near as possible to the centre of plan area and as far as possible from the rotor assembly, two requirements which were not easy to meet. If the sensing aerial had to be mounted aft of the ideal position it usually resulted in the bearing-indicator needle reversing after the aircraft had passed over the beacon.

On a single-rotor helicopter, the loop aerial could be mounted either above the cabin or on the upper side of the tail boom abaft the rotor head. The latter position had been found to give less susceptibility to modulation effect and random errors. Instrumental accuracy of the radio compass was approximately ± 1 deg and overall operational accuracies in the region of ± 3 deg had been obtained.

MR. HINCHLIFFE described installation and operation of the Decca Navigator. Again, aerial location was of prime importance and was complicated by the fact that the first valve of the receiving unit had to be within one foot of the aerial. Therefore, apart from other considerations, there had to be space inside the fuselage adjacent to the aerial attachment point to accommodate the aerial amplifier unit; but the problems were not insurmountable, and many successful installations had been made. Mr. Hinchliffe re-iterated the plea of the other speakers in asking for more consideration from helicopter designers in the early stages of any new type. More "systems engineering" was needed, the helicopter, its instruments, radio communication system and navigational aids being considered as an integrated whole.

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Naval Aviation Prospects

A Broad Review by Rear Admiral Cambell at Hull

The lecturer (right) and Sir John Slessor, a Blackburn director, arriving at Brough.

RECENTLY appointed Flag Officer Flying Training, Royal Navy, Rear Admiral D. R. F. Cambell, D.S.C., was the speaker at the fourth Sir George Cayley memorial lecture of the Brough branch of the Royal Aeronautical Society at Hull on Wednesday, November 13. Originally the lecture was to have comprised an historical survey of naval aviation by Rear Admiral C. L. G. Evans: deputizing at short notice, Admiral Cambell chose to discuss the wider implications of the value and prospects of the Fleet Air Arm at present and for the future.

Introducing the lecturer, Mr. M. G. K. Byrne, chairman of the Brough branch and publicity manager of Blackburn and General Aircraft, disclosed that the next Cayley lecture would consist of a history of the Blackburn company (which celebrates its 50th anniversary in April 1959), to be given by Mr. G. E. Petty.

After tracing the ways in which the use of air power had transformed sea warfare, Admiral Cambell described the postwar series of Fleet Air Arm aircraft and the problems of their procurement. Political delays and arguments, he reckoned, had cost up to three years in the life of each machine.

Developments in aircraft carriers and their equipment were next considered by the speaker, who went on to refer to the Fleet Air Arm's rôle in the Suez campaign. The most recent phase had followed the Government re-thinking which culminated in the Defence White Paper earlier this year. It appeared that the Government favoured the concept of a carrier force as a "wandering fire-brigade" but doubted the Navy's place in a global war.

The present era was one of modernization for the carrier force. *Ark Royal, Eagle* and the three *Centaur*-class carriers would be joined by the modernized *Victorious* and the much-modernized *Hermes*. Aircraft would include the Scimitar fighter and part-time strike aircraft, which could carry an atomic weapon, and the NA-39 strike machine.

The Navy's existing carriers, the lecturer said, would last until the early 1970s. After this stage we could not hope to modernize —we should certainly not be able to accept bigger aircraft, for we were up against the stops now. If there was to be a further stage, completely new designs of carriers and aircraft would be needed. And if the decision was made to do this, no results could be expected before 1967. Radical new developments in technique such as VTOL aircraft and guided reconnaissance machines (which could take photographs and return to base) might well be applied to carrier operation.

Admiral Cambell concluded his lecture with nine points: —

"1. Nothing that has emerged in the field of ultimate weapons so far can make the Navy obsolete. Long-range ballistic missiles do not seem to apply at sea, and other forms of attack are vulnerable to Fleet defensive measures.

"2. If global war does become protracted (for any one of a number of reasons), defence of sea communications to and from the United Kingdom will be the Navy's job again as in the past.

"3. For limited war and associated threats, for cold war, imperial policing, for goodwill visits and prestige purposes, the Navy has a perpetual mission which cannot be done as well or as cheaply by any other Service or agency.

"4. I think manned aircraft will remain in the Navy for purposes of offence, defence and surveillance, but the trend of development will be diverted from the aircraft itself and transferred to its equipment. For surface strike and for air defence I visualise the development of a (possibly common) long-endurance aircraft of moderate speed and ceiling, launching guided missiles of high performance.

"5. To replace the close-range defence gun system, ship-to-air guided weapons will be a most effective substitute. But I doubt whether it will be practical or economical to develop a long-range guided weapon to replace the naval fighter unless some other customer—the R.A.F. or the U.S.N., for example—has similar needs and can share with us the burden of such a development.

"6. The future of the helicopter at sea is very bright. For anti-submarine work it is proving highly effective. For imperial policing and minor localised affrays, the helicopter commando-carrier concept offers great hopes of a versatile and economical instrument.

"7. I hope we shall see another generation of aircraft carriers on the stocks before long, but they must be matched by a new generation of aircraft.

"8. In general, I rather agree with Mr. Nehru that the march of science has outrun Man's social sense. With the planets now within almost practical grasp, it is ludicrous that we should still have to practise the art of cutting each other's throats. But so long as international affairs are dominated by the East-West enmity, we cannot afford to relax the tempo of defence and it is unwise, if not immoral, to leave the naval effort entirely to the U.S.A.

"9. Our powerful sister service, the United States Navy, pays more than token respect to the Royal Navy; Hanson Baldwin said recently in the *New York Times* that few U.S.N. carriers could match the *Ark Royal's* standard of training and proficiency in Exercise Strikeback."

Opening the discussion on the lecture, Marshal of the R.A.F. Sir John Slessor asked whether the trend towards big carriers was the right one; whether the atomic-powered surface carrier was a necessary intermediate step before the underwater carrier equipped with guided weapons; and whether catapults and arrester devices could be adapted for land-base use in order to restore mobility to tactical air forces. Admiral Cambell replied that large carriers were better able to operate in bad weather, but they introduced docking difficulties—30,000 tons was a good, practical size. The only great advantage of a nuclear-powered carrier was its endurance (but replenishment involved items other than ship fuel); and it should be remembered that a nuclear submarine with guided weapons would lack the carrier's flexibility.

The question of the vulnerability of the aircraft carrier, not unnaturally, soon arose in the discussion. The carrier was no more vulnerable than land bases, the lecturer claimed, for each could be attacked both by bombing and by submarines with guided weapons. The development of a large number of very small underwater carriers, suggested by one speaker, was theoretically attractive but impracticable, in Admiral Cambell's opinion.

Asked when it was that the Royal Navy had changed its mind and had begun to believe in aviation, the lecturer told a story based on a classic example of the old attitude. This episode took place in the North Sea during the early days of the last war, and concerned a bombing attack on a group of British warships which included *Ark Royal* and two battleships. To the frustration of *Ark's* squadrons, the carrier was ordered to strike-down all its aircraft below the deck, to remove all fuel from them, and to fall in line behind the battleships and fire its anti-aircraft guns at the attacking bombers. The change in attitude came, Admiral Cambell suggested, when the bombs began to fall.

CLUB AND GLIDING NEWS

MEMBERSHIP of the Kronfeld Club, the basement meeting-place for gliding and light-aircraft enthusiasts at 74 Eccleston Square, London, S.W.1, is now approximately 250, it was reported at the recent a.g.m. The committee for this year comprises Hugo Trotter (hon. secretary), Maurice Imray, Mrs. Yvonne Bonham, Ron Willbie, David Smith, David Carrier and Denis Monckton. Miss Penny Taylor of the Southdown Gliding Club has taken over the production of the club's newsletter.

WINNER of this year's competitions for the J. Y. Watson Cup at the Scottish Aero Club, Perth, is A. McLennan. Second and third places were taken by members Nicol and Simpson respectively. Last month's first soloists included R. D. Burns, J. Balman and J. Paul, while D. Grieve and C. Martin obtained P.P.L.s.

CLUB competitions at Elstree have been won by C. O. Vernon, technical knowledge; D. Trigg, navigation; E. Wells, forced landing; W. Heywood, circuit; and P. Laffy, student pilot. The title of club champion for 1957 goes to David Trigg, for the highest total in all the contests combined. Night cross-countries for C.P.L. students at Elstree are due to begin on Tuesday next, November 26.

CONGRATULATIONS to the Warwickshire Aero Club for winning the Popular Flying Association's Masefield Trophy for 1957 were voiced by Mr. Maurice Imray, P.F.A. secretary, at the club's annual dinner at Elmdon on Saturday last, November 16. The award was made, he said, on the basis of performance, safety and facilities; Warwickshire was the only P.F.A. club offering night flying, and its syllabus was second to none. Sir Robert Marriott deputized at the dinner for the Earl of Warwick, president of the club.

A FORMATION flight of four Tiger Moths from Roborough to Dartmouth, Exeter and return on October 28 completed the final sortie of the sixth year of training by Plymouth Aero Club for midshipmen of the Royal Naval College, Dartmouth. This year's Naval flying at Roborough has constituted a record level of activity, with 154 midshipmen and cadets attending and logging a total of 937 hours since March 3. Of these pupils, 83 undertook progressive flying training courses of varying lengths, with an average duration of just over ten hours; and the remaining 71 received air experience in the form of *ab initio* flying instruction varying from 1½ to four hours each. Roborough's three Naval Tiger Moths were flown up to R.N.A.S. Lossiemouth for the midshipmen's flying camps during the summer leave period.

SERVICE AVIATION

Royal Air Forces and Naval Aviation News

Maintenance Command C-in-C.

AN Air Ministry announcement states that the Queen has been pleased to approve the appointment of A.V-M. Harold Douglas Jackman, C.B., C.B.E., as A.O.C-in-C., R.A.F. Maintenance Command, with effect from May 1958, in succession to Air Marshal Sir Richard B. Jordan, K.C.B., D.F.C., who will be retiring from the Royal Air Force. A.V-M. Jackman has been Director-General of Equipment at the Air Ministry since August 1955, and before that was, for three years, A.O.C. No. 40 (Maintenance) Group.

Halton Ceremony

THE Argentine School of Military Aviation is presenting annually to the Royal Air Force a sword, to be awarded to the best cadet passing out from the R.A.F. College, Cranwell, or from the R.A.F. Technical College, Henlow; and a gold medal, to be presented to the best apprentice passing out from the R.A.F. Apprentice Training Schools (Halton, Locking and Hereford).

The first sword (for 1956) went to P/O. J. H. Constable, who passed out with the 68th Entry from the R.A.F. College, and the first gold medal was awarded to Tech. Cdt. N. E. Trigg, who passed out with the 76th entry of aircraft apprentices at No. 1 School of Technical Training, Halton, and is now a cadet at the R.A.F. Technical College, Henlow. The presentations were made at a ceremony held at R.A.F. Halton on November 14 during a visit to Halton by a party of 37 cadets from the Argentine School of Military Aviation. A parade of Halton apprentices took part in the ceremony and the presentations were made by the Argentine Air Attaché, Comodoro Baldomero Llerena. The ceremony was watched by His Excellency the Argentine Ambassador, Señor Alberto Maria Candioti.

R.A.F. Benson Honoured

ON November 13 the Freedom of the Borough of Wallingford, Berks, was presented to the neighbouring R.A.F. Station, Benson. Those attending the ceremony included the Under-Secretary of State for Air (Mr. C. I. Orr-Ewing, M.P.), the Air Member for Personnel (Air Marshal Sir John R. Whitley), the Air Officer Commanding-in-Chief, R.A.F. Transport Command (Air Marshal Sir Andrew McKee), the Lord Lieutenant of Berkshire (Mr. H. A. Benyon), the High Sheriff of Berkshire (the Hon. Edward Langton Iliffe), and the High Steward of Wallingford (Lord Glyn of Farnborough). The Mayor of Wallingford, Councillor W. Mason, presented the Scroll conveying the Freedom to the Officer Commanding, R.A.F. Benson, G/C. D. H. Lee, D.F.C.

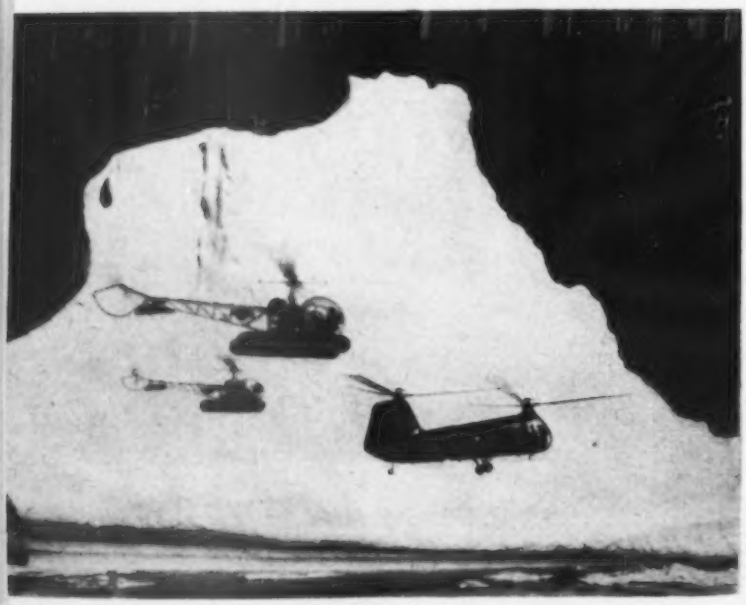
Best University Air Squadron

THE University of London Air Squadron (W/C. N. Cameron, D.S.O., D.F.C.), based at R.A.F. Biggin Hill, has been adjudged the best of the 17 University Air Squadrons in the United Kingdom, and has won the 1957 Hack Trophy Competition. This is London's first success with the trophy, which was presented in 1943 by W/C. E. J. Hack for annual award to Britain's best all-round University Air Squadron.

In this year's competition, London obtained 752 marks. Birmingham came second with 701 marks and Durham third with 608 marks. A congratulatory letter has been received from the A.O.C-in-C. R.A.F. Home Command, Air Marshal Sir Douglas Macfadyen, the squadron's first adjutant.

Awards for Gallantry

THE Queen has been graciously pleased to approve the following awards in recognition of gallantry:—*Military Cross:* Act. S/L. R. C. Snashall, R.A.F. Regt., for gallantry during operations in the Western Aden Protectorate in 1955 and 1956 and more recently in the Dhala area ("His command of his squadron, often under enemy fire, has been exemplary"); Yuzbashi Abdullah Ali Audhali, Aden Protectorate Levies, for gallantry on January 27, 1957, when No. 9 Sqn., of which he was a member, was twice involved in fierce and potentially dangerous engagements with Yemini Army Units ("The success achieved was largely due to his actions and example"); *Military Medal:* Sgt. J. F. Molyneux, R.A.F. Regiment, for his "skill, tenacity and bravery" on January 27, 1957, when No. 10 Armoured Car Squadron, under his command, was involved in an action with No. 9 Squadron against Yemini Army Forces.



Above right, the Argentine Air Attaché, Comodoro Baldomero Llerena, presents the Argentine School of Military Aviation sword to P/O. J. H. Constable, of the 68th Entry, R.A.F. College, Cranwell, as recorded in a paragraph ("Halton Ceremony") above.

Left, a Vertol HUP and two Bell HTLs from H.M.C.S. "Labrador," the Arctic patrol ship which has made four voyages to the far north under the white ensign, seen against a tremendous "cathedral" iceberg.

IN BRIEF

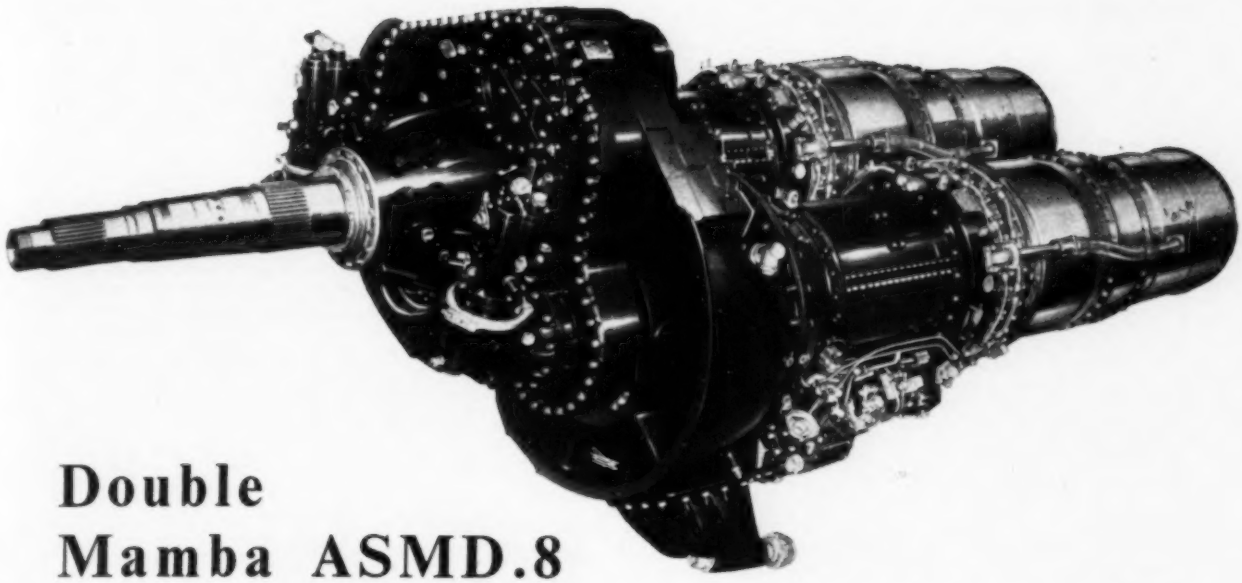
A REUNION of former members of the R.A.F. and Fleet Air Arm who served during the war at the U.S. Naval Air Station, Pensacola, will be held in London on November 26. Particulars can be obtained from Mr. L. V. Armstrong, 47 Rutland Road, Wanstead, London, E.11 (Tel. WANstead 7217).

* * *

To mark the forthcoming presentation of No. 65 Squadron's Standard it is intended to produce a squadron history. Readers willing to lend photographs, cuttings, etc., or who can set down simply any interesting incidents they recall, are invited to contact the squadron adjutant of No. 65 Squadron, at Royal Air Force Duxford, Cambs.

* * *

No. 38 Squadron is now 25 years old and is anxious to revise, expand, and, if possible, illustrate, its squadron history. W/C. H. M. S. Green would be grateful if any relevant photographs or information could be forwarded to him at the following address: No. 38 Squadron, Royal Air Force, Luqa, Malta, G.C. The greatest possible care will be taken of any material lent to the squadron.



Double Mamba ASMD.8

Development of Armstrong Siddeley's Double Turboprop

THE roots of the ASMD.8 extend back to the earliest turbine engines built by Armstrong Siddeley Motors. The design of the Mamba followed on from such powerplants as the ASX and the Python, design of which was started in 1942, and development of the Double Mamba has always been closely integrated with that of the single engines which form its power sections. The single Mamba was built to meet the same 1945 specification for a 1,000 h.p. turboprop for trainers and light military aircraft that led Rolls-Royce to design the Dart. Early Mambas were installed in the Athena and Balliol, and it was a change in ministerial policy rather than any basic trouble with the Mamba that resulted in a Merlin-engined Balliol being adopted. There were development problems with the engine, of course, but these were all eventually overcome. Another aircraft powered by the Mamba, it may be recalled, was the Apollo built by the nearby firm of Armstrong Whitworth; Mamba powerplants were chosen instead of contemporary Darts, Merlins or Cyclones.

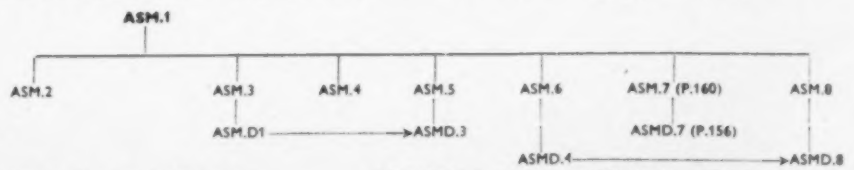
This first Mamba was the ASM.1, rated at 1,010 s.h.p. and with 307 lb jet thrust. As early as 1948 this engine had carried out a 500-hour test at about 980 s.h.p. It had ten compressor stages, two turbine stages and six combustion chambers. When originally conceived it also had a two main-bearing lay-out and a high-pressure fuel system, but to the former was added a third main bearing when differential expansion problems were encountered between the blading and casings, and an Armstrong Siddeley vaporizing fuel system with superior characteristics at altitude was soon adopted, and no high-pressure system has been used since.

The next major design change came with the ASM.3. There were again ten compressor stages but the mass flow was raised from 13.5 lb/sec to 17.5 lb/sec by removing the two aftermost high pressure stages and adding two additional stages at the front of the engine. The inlet annulus was also increased. Thus, at an early development stage, the rated power was raised to 1,270 s.h.p.

The genesis of the Double Mamba was an Operational Requirement issued to aircraft manufacturers for a Naval carrier-borne anti-submarine and reconnaisance aircraft; discussions between Fairey and Blackburn, the Ministry of Supply and Armstrong Siddeley suggested that a form of double turbine engine would be suitable, since there was no single large piston engine that could meet the Operational Requirement as laid down. The requirement was indeed of a very specialized nature. Naval aircraft of this type require a great deal of take-off power for a short take-off run with a high load, but the cruising speed requirements for extended patrols are small, and while piston engines have a good specific consumption at low loads the reverse is the case with a turbine powerplant. A large single turbine would have shown rather poor comparative specifics even at take-off power, and at 50 per cent of this power the consumption would have been considerably worse. Hence, a large turbine engine (the Clyde, Python or Proteus might have been considered) would not have been satisfactory and a conventional twin-turbine-engined layout using single Mambas would have been unsuitable for similar reasons. Yet the eventual solution—to couple two single Mambas so that they drove co-axial propeller shafts but otherwise operated completely independently—was a happy one, for it gave the Navy the turbine engine they wanted and solved the problem of single-engined flight in the cruise condition.

An objection raised at this time that a failure of one power section might affect its neighbour has not been encountered in practice, and in many thousands of hours it has been fully demonstrated that the arrangement is an inherently safe one. Although, due to the additional gearing, a certain weight penalty resulted from this double lay-out, the engine plus fuel weight for the type of mission envisaged in the Requirement is better than the equiva-

The Mamba family tree, covering nearly twelve years. Single power sections have been used to develop double engines.



ASM.1: 10a, 2T, 6 cc, 1,010 s.h.p. 307 lb. As ultimately run had three bearings and vaporizing combustion chambers.

ASM.2: Not built.

ASM.3: 10a, 2T, 6 cc, 1,270 s.h.p. 384 lb. Redesigned compressor, increased mass flow, three main bearings. Produced in small quantities.

ASM.4: As ASM.3 but with *ann* chamber. Never built.

ASM.5: 10a, 3T, *ann* vaporizing chamber, 1,400 s.h.p. Development tool only for ASMD.3.

ASM.6: 11a, 3T, *ann*, 1,650 s.h.p. 365 lb. As ASM.5 but "zero-stage" compressor. Produced for Seamew and as development tool for ASMD.4.

ASM.7: 12a, *ann*, 2+2T (two free turbine stages). 2,430 s.h.p. Based on ASM.6, but not built.

ASM.8: 11a, 3T, *ann*, 1,950 s.h.p. Nimonic 100 turbine blades; used as development tool for ASMD.8.

ASMD.1: First Double Mamba, based on 2 x ASM.3. In service at 2,540 s.h.p. 925 lb.

ASMD.3: Reduction gear as ASMD.1, power section 2 x ASM.5. In production and service at 2,800 s.h.p. 900 lb.

ASMD.4: First engine with lowered thrust line and double-helical reduction gears. Development only.

ASMD.7: As ASMD.4, but with ASM.7 power sections. Rated at 4,400 s.h.p. but not built.

ASMD.8: As ASMD.4 but with ASM.8 power sections. In production at 3,600 s.h.p. 710 lb.

Notes: a—axial compressor stage; T—turbine stages; cc—combustion chambers; *ann*—annular combustion chambers.

DOUBLE MAMBA ASMD.8 . . .

lent figure for a piston-engined aircraft.

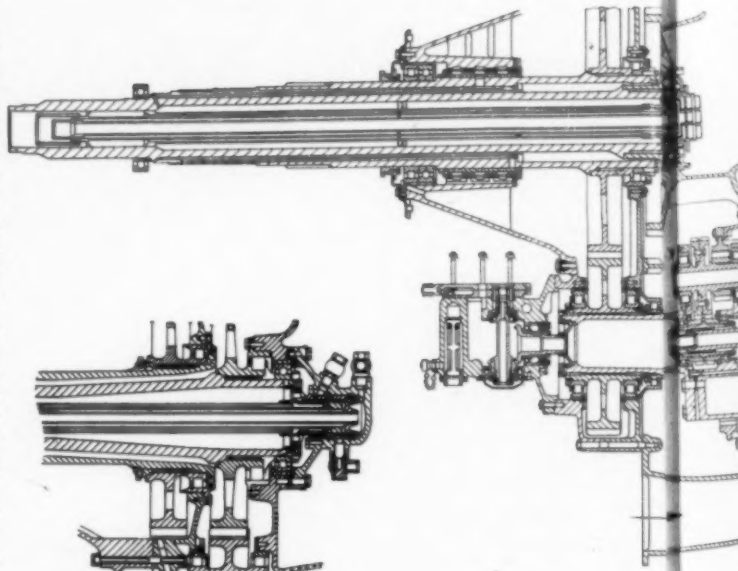
After the issue of the O.R. two tenders were accepted; the Gannet from Fairey and the YB-5 from Blackburn. It has now, of course, passed into history that the Gannet was the aircraft chosen for the Royal Navy and the development of the Double Mamba engine has since been closely associated with this airframe.

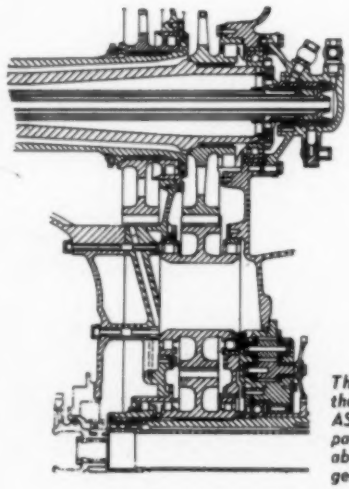
The Mamba 3 was chosen as the basis of the first Double Mamba —the ASMD.1—and the independence of the two power sections was made as complete as possible. The accessory gearbox, for example, can be driven through gears and freewheels from either engine. The starting systems too, are independent, although it is normal procedure to perform a cartridge start on one engine, to accelerate it, and start the other engine by unfeathering the propeller—either engine can be started from the other.

Discussions between the M.o.S. and firms concerned and preliminary design work took place in early 1947, and in September 1948 the first Double Mamba development engine completed a two-hour acceptance test. Remarkably few changes had to be made to the ASM.3 power sections. The reduction ratio in the compound epicyclic gearing, which was chosen to suit faster aircraft than the Gannet, was modified and the ratio between compressor speed and propeller shaft speed, affected by both reduction and transfer gears, was changed from 0.0846 : 1 (Mamba 3) to 0.0961 : 1 (Double Mamba 1). Another obvious change was to the method of mounting; the single engine was supported by a six point pick-up on the centre section, and in the two power sections of the double engine this casing was redesigned and a three point mounting was built into the gear casing from which the power sections are cantilevered. There are two airframe-mounting ball joints at the lower corners of the engine and a further one centrally above. For installation purposes it was obviously necessary to redesign the exhaust cones and the operational need to be able to use fuel of various densities (aviation kerosine, wide-cut gasoline and diesel oil) resulted in the replacement of the swash-plate type of fuel pump by one of Dowty design, in which the governor would not have to be re-adjusted for each change of fuel used.

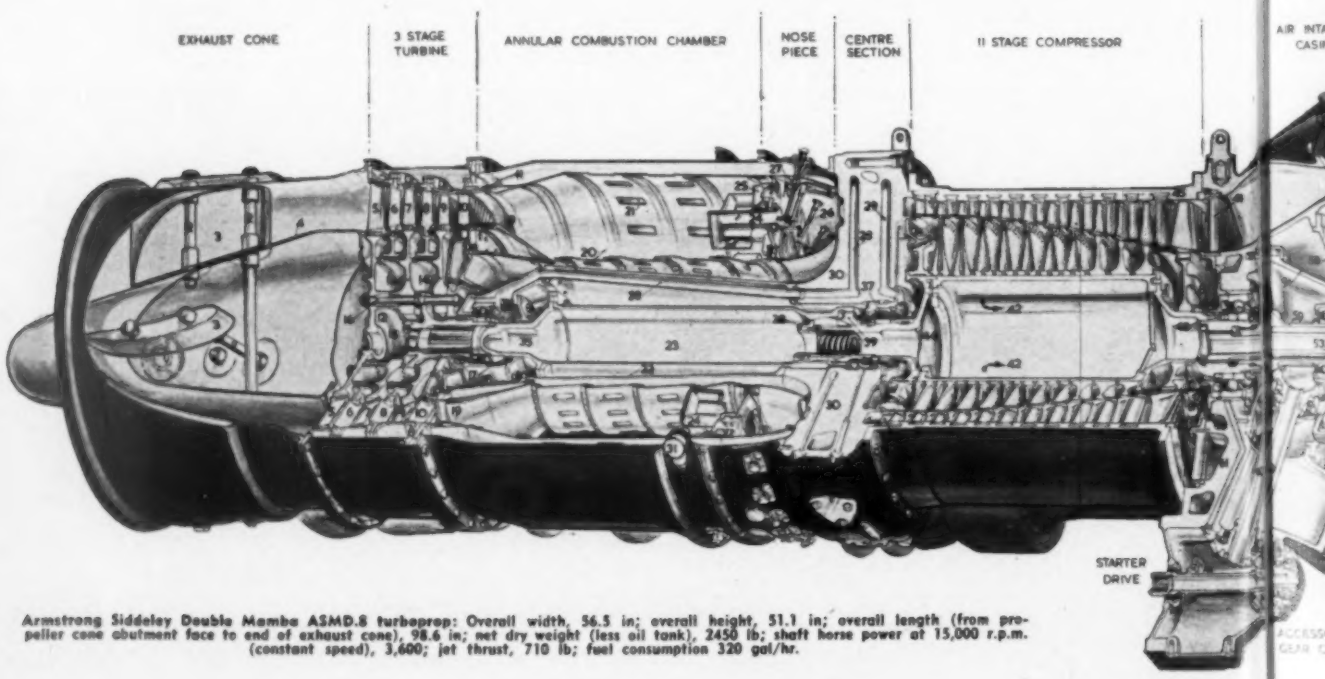
Destined as the Double Mamba was for the peculiar needs of carrier operations, some changes were also made to the engine-speed control system. Instant increases in power are needed in the event of wave-off, and similarly, it must be possible to decrease power very rapidly at the moment of touch-down. Rapidity of thrust response to throttle movement in turbine engines of this period was generally rather poor and in any variable speed engine the problems of jet pipe temperature limits and compressor surge have to be overcome. This led to the adoption of a constant speed engine with all power changes being made by attention to the fuel flow and propeller pitch. The small loss in cruise efficiency

Intake, combustion and cooling airflow paths are shown on this sectional diagram of the ASMD.8. Cooling air is indicated with dotted arrows. A diagonal section has been taken to show the true centre lines of the co-axial propeller shafts and port power section.



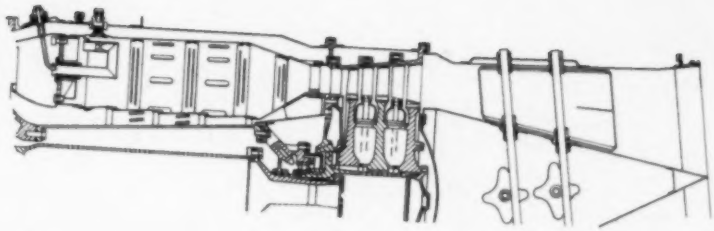


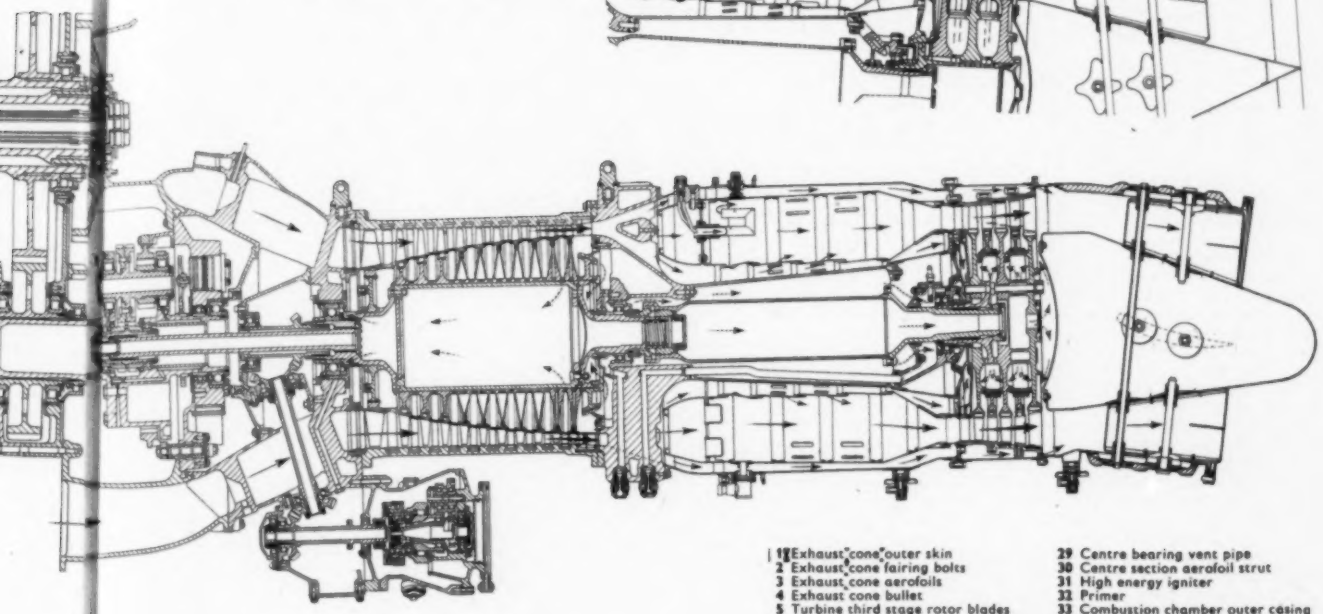
This enlarged section through the reduction gearing of the ASMD.3 should be compared with the drawing above. Note the simplified gearing of the later engine.

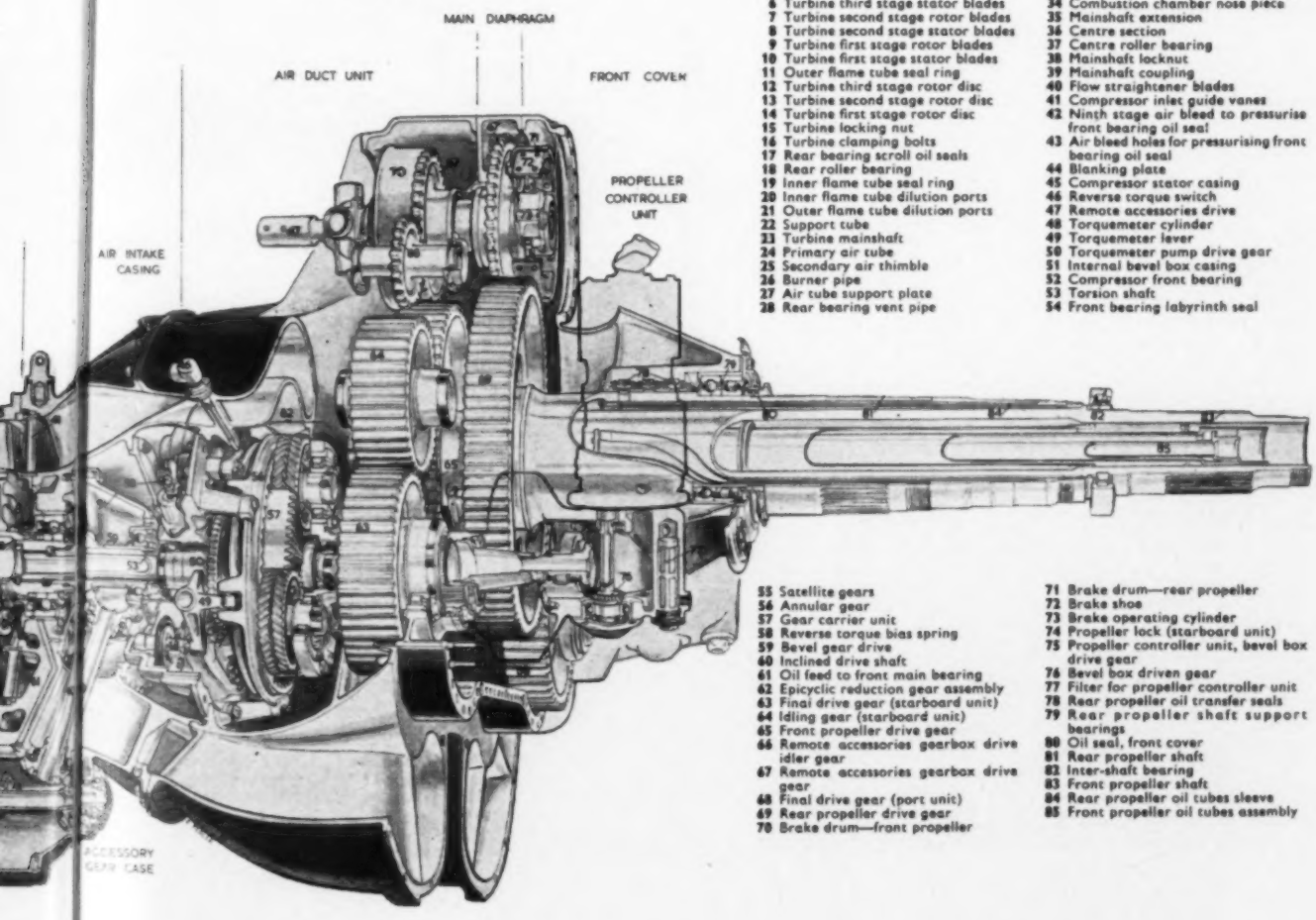


Armstrong Siddeley Double Mamba ASMD.8 turboprop: Overall width, 56.5 in; overall height, 51.1 in; overall length (from propeller cone abutment face to end of exhaust cone), 98.6 in; net dry weight (less oil tank), 2450 lb; shaft horse power at 15,000 r.p.m. (constant speed), 3,600; jet thrust, 710 lb; fuel consumption 320 gal/hr.

The overhung turbine and annular combustion chamber of the earlier ASMD.3. Profiled exhaust cone aerofoils appreciably raised the turbine efficiency of the ASMD.8.







1 Exhaust cone outer skin
2 Exhaust cone fairing bolts
3 Exhaust cone aerofoils
4 Exhaust cone bullet
5 Turbine third stage rotor blades
6 Turbine third stage stator blades
7 Turbine second stage rotor blades
8 Turbine second stage stator blades
9 Turbine first stage rotor blades
10 Turbine first stage stator blades
11 Outer flame tube seal ring
12 Turbine third stage rotor disc
13 Turbine second stage rotor disc
14 Turbine first stage rotor disc
15 Turbine locking nut
16 Turbine clamping bolts
17 Rear bearing scroll oil seals
18 Rear roller bearing
19 Inner flame tube seal ring
20 Inner flame tube dilution ports
21 Outer flame tube dilution ports
22 Support tube
23 Turbine mainshaft
24 Primary air tube
25 Secondary air thimble
26 Burner pipe
27 Air tube support plate
28 Rear bearing vent pipe
29 Centre bearing vent pipe
30 Centre section aerofoil strut
31 High energy igniter
32 Primer
33 Combustion chamber outer casing
34 Combustion chamber nose piece
35 Mainshaft extension
36 Centre section
37 Centre roller bearing
38 Mainshaft locknut
39 Mainshaft coupling
40 Flow straightener blades
41 Compressor inlet guide vanes
42 Ninth stage air bleed to pressurise front bearing oil seal
43 Air bleed holes for pressurising front bearing oil seal
44 Blanking plate
45 Compressor stator casing
46 Reverse torque switch
47 Remote accessories drive
48 Torquemeter cylinder
49 Torquemeter lever
50 Torquemeter pump drive gear
51 Internal bevel box casing
52 Compressor front bearing
53 Torsion shaft
54 Front bearing labyrinth seal

55 Satellite gears
56 Annular gear
57 Gear carrier unit
58 Reverse torque bias spring
59 Bevel gear drive
60 Inclined drive shaft
61 Oil feed to front main bearing
62 Epicyclic reduction gear assembly
63 Final drive gear (starboard unit)
64 Idling gear (starboard unit)
65 Front propeller drive gear
66 Remote accessories gearbox drive idler gear
67 Remote accessories gearbox drive gear
68 Final drive gear (port unit)
69 Rear propeller drive gear
70 Brake drum—front propeller
71 Brake drum—rear propeller
72 Brake shoe
73 Brake operating cylinder
74 Propeller lock (starboard unit)
75 Propeller controller unit, bevel box drive gear
76 Bevel box driven gear
77 Filter for propeller controller unit
78 Rear propeller oil transfer seals
79 Rear propeller shaft support bearings
80 Oil seal, front cover
81 Rear propeller shaft
82 Inter-shaft bearing
83 Front propeller shaft
84 Rear propeller oil tubes sleeve
85 Front propeller oil tubes assembly

which results from this arrangement was found to be relatively insignificant. (These problems were discussed at length in an article on Double Mamba Progress in *Flight*, March 4, 1955).

In this new engine Rotax twin-breech starting was used on the Mamba for the first time and Lockheed propeller brakes, required in carrier operation to prevent auto-rotation, were introduced into the gearbox main diaphragm. Some of these problems were also to be encountered with the Mamba 3s installed in the carrier-borne Sturgeon and the Breguet 960. Another refinement made on the Double Mamba was the introduction of propeller synchronizers to prevent stroboscopic shadows.

Direct application of the single Mamba power sections to the double engine has made it possible throughout the development of the ASMD series to do performance development on single Mamba units and to do mechanical work on the double engine. The design power of 1,270 s.h.p. was achieved on a Mamba 3 engine in 1950, and the efficiency of the double unit was such that twice this power was achieved on the Double Mamba 1.

Development on double and single engines then proceeded side by side. Problems encountered were relatively few but, as with all engines in which progressively greater powers are achieved, various troubles were encountered and corrected as the design progressed. After the inlet guide vanes had been adjusted to give the optimum performance and mass flow, compressor fatigue failures associated with aerodynamic flutter were encountered, and this led to the adoption of steel blades for the first four and last two stages. As experience was accumulated, development progressed with the method of welding the outer flame tubes; the shape and spacing of the combustion chamber dilution ports was altered to obtain better turbine inlet temperature distribution and the combustion chamber vaporizing tubes—the "walking sticks"—were re-designed. This was part of general Armstrong Siddeley development. The radiused walking stick handles were changed to a type with the two right-angle bends, and lateral turbulence pins were introduced into the parallel section of the tubes. Other changes in the materials and design of the combustion chamber were made to accommodate the higher sulphur content permitted in the specification of JP4 wide-cut fuel.

While development was continuing on the power sections of the engine, work was also being done to develop the reduction and transfer gear trains. Breakdowns had occurred on the high-speed portions of the epicyclic gearing, to the teeth of the sun and satellite wheels. This was found to be due to minute imperfections in the geometry of the teeth as they came into mesh, resulting in impact instead of rolling loading. A change in the tooth profile improved matters, but problems affecting the satellite gear bearings were not entirely solved when the double engine came along. Due to high tooth parting loads and the configuration of the gear trains, the thrust and roller bearings are heavily loaded, and a good deal of development work was required to bring the gearbox to a high standard of reliability.

The ASMD.1 passed its official 150-hour type test in early July 1955, and went into production in March 1952. Some 19 150-hour tests were carried out at various modification stages until production ceased in December 1955. Large numbers of Double Mamba 1s are now in service as the ASMD.1 Mark 100.

Inevitably, as development of the Gannet progressed, the all-up weight of the aircraft increased and the engine manufacturers were asked to provide additional shaft horse-power from the Double Mamba. The logical way of doing this was to take more work out of the gas stream by introducing a three-stage turbine; a step which provided the engine manufacturers with the opportunity to reduce individual stage loadings. The three-stage turbine engine, using ASM.5 power sections, was designated ASMD.3. The fuel flow was no greater than that of the D.1 but the shaft horse-power was increased and specific consumption was improved. No alteration was made to any part of the engine forward of the compressor, but with the additional turbine stage an annular combustion chamber—offering various structural and thermodynamic advantages—was introduced. This step gave the engine additional stretch, since for a given envelope size an annular combustion chamber offers higher power and greater heat release and preserves the operating parameter of C.H.U./cu ft/hr/atmosphere.

Another change that was made to the engine at this stage was the introduction of a flood-feed oil-cooled lubrication system instead of a total loss, micro-pump system using air-blast cooling. As an oil cooler was in any case required in the reduction gear lubrication circuit, it was logical to increase the size of this unit slightly to cater for main bearing oil.

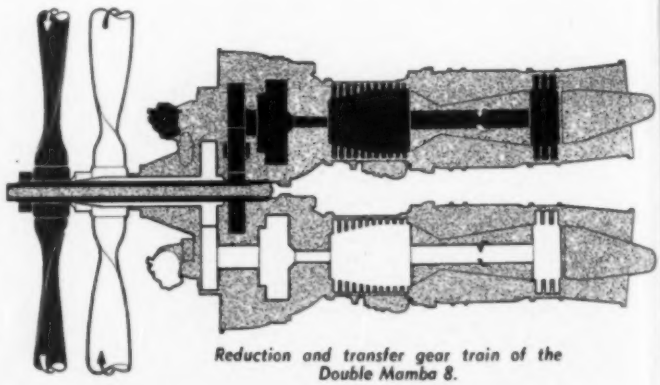
The engine in this form went into production in January 1956, following the official type test in July 1955, at more than 2,740 s.h.p. and 820 lb thrust. The engine was certified at 2,800 s.h.p. and 900 lb thrust, after allowances had been made for intake and jet pipe losses. There have been nine 150-hour development tests.

Later in the life of the Gannet airframe, the installation of certain new equipment led to a request for the thrust line of the engine to be lowered in relation to the centre line of the power sections, so that the whole engine could be raised within the airframe. Additional power was also sought. By this time the ASM.6 Mamba was already available in single form and the only remaining step was to develop an entirely new reduction and transfer gearbox and air-intake assembly. Although this was a major proposition, it was possible to make provision for handling more power than would be provided by two ASM.6s, and during re-design, the reduction gearing was stressed to handle 4,400 s.h.p. ($2 \times 2{,}200$ s.h.p.). Originally conceived as the ASMD.4, this engine had ASM.6s with eleven stage compressors as the power sections; the additional blading being a zero stage giving a mass flow increase from 2×17.5 lb/sec to 2×21 lb/sec.

While this D.4 version was being developed, work continued on single engines—particularly with Nimonic 100 rotor blades—bringing the ASM series up to eight, and the power up to 1,950 s.h.p. This power section was married to the strengthened reduction gearing and the double engine then designated ASMD.8.

An alternative development that was studied by Armstrong Siddeley while work was beginning on the D.4 three years ago, was a project design for single and double Mamba 7s, rated at 2,430 s.h.p. and 4,200 s.h.p. These represented a fairly major departure from the single and double Mamba series up to that date. They were to have had 12-stage compressors and four-stage turbines, the two last (power) stages of which were free; although there was undoubtedly considerable development potential in a basic re-work of this nature, it was realised that the single and double Mamba 8s would achieve nearly the same result in terms of immediate performance increase for less development effort and for a lower weight, and the project engines designated P.160 and P.156 remained shelved.

In general, the ASMD.8 follows the lay-out of its predecessors, except for a lowering of the thrust line which reduces the offset between the propeller centre line and the power section from 11in to six. As before, the power sections function independently. Both are self-contained, so that in the event of the failure of one power section, it is possible to remove it from the reduction gear assembly and substitute a sound unit. As a direct result of the design of the engine and the intended method of operation, the Double Mamba possesses what is probably a unique method of measuring engine life. This is, of course, normally expressed in hours run, but for



Reduction and transfer gear train of the Double Mamba 8.

the typical single-engined operation of the Double Mamba in Naval service, each power section is fitted with a life-recording revolution counter. The hours of operation can be deduced from the fact that the engine operates at a constant r.p.m., and as a working basis one million revolutions represents one hour's running time. This enables the pilot to make equal use of the port and starboard power sections of the double unit.

Mechanical Design. The common reduction gear casing is in three sections; the front cover, an intermediate diaphragm, and an air duct unit into which are cast the intakes to the two power sections. The front cover, cast in D.T.D.748 light alloy, houses the co-axial propeller shafts and their bearings and the two low-pressure Rotax air starters, with the attendant gearing and engagement mechanism. The front cover and intermediate casing is extended upwards on the centre line of the engine to accommodate the two internal-expanding-shoe propeller brakes operating on the transfer gearing. These are operated by engine oil supplied from a spring-loaded hydraulic accumulator. Bolted to the rear face of the intermediate diaphragm is the main Hi-duty alloy casting air duct unit carrying the three mounting feet. This main casing contains the idler gears and aircraft accessory drive gearbox, which by a system of freewheels, permits either power section to supply the full accessory load of 200 b.h.p.

The gear train can be followed from the sketch on this page.

Reduction takes place in two stages; the first in the epicyclic gear box and the second through the spur gears of the transfer train.

Input from the power sections is *via* a compressor extension shaft splined into the rotor and carrying a double-helical sunwheel at its forward end. Meshing with the sunwheel are three double-helical satellite gears which carry on a common shaft smaller diameter straight-cut spur gears running in an internally-toothed ring restrained against rotation by the torquemeter mechanism.

Essentially, this consists of arms on the ring gear which are attached to hydraulic pistons. As torque increases, a corresponding increase in hydraulic oil pressure at the pistons is transmitted to the torquemeter pressure indicator, where it is read-off as s.h.p.

Rotation of the spur gears around the toothed rack rotates the split satellite carrier. This is a large steel forging carrying the roller bearings of the three satellite/spur gear combinations. The inside faces of the two sections are pocketed to accommodate the spur and satellite gears and a Hirth coupling is formed on the two abutting faces. The two halves are rigidly bolted together after the spur and satellite gears are inserted. The forward section of the carrier is extended to form a splined shaft which carries a large spur gear forming the pinion of the transfer gear train and an interposed idler transmits the drive into a further spur gear splined to the inner propeller shaft. The drive from the port power section is similar except that gear sizes in the transfer train have been chosen so that counter-rotation can be obtained by omitting the idler. The accessory drive is taken through spur gears of reduced width meshing with the propeller shaft gearing of the main drive. Output is *via* a Hardy Spicer joint and a suitable extension shaft.

An internal drilling in the accessory drive gearbox casting carries a supply of pressure oil to each of the bearings in the accessory drive gear train and a "one-shot" lubricator maintains oil level in the housing by an injection at each engine start. Further drillings carry oil to each of the bearings in the reduction gearbox. Oil collects at the lowest point of the casing and is directed through a passage to the scavenge filter, scavenge pump, and *via* the 8in-diameter, 21-h.p. oil cooler.

Each power section has its own annular air intake casing bolted to the rear face of the air duct unit gearbox casing. Aerofoil section webs carry the internal wall and a large boss supporting a front main bearing. Into a machined register in the rear face of this casing are fitted the carrier rings to which the inlet guide veins are slotted, and grub screws pressing axially into the stator casing prevent rotation. Through one of the hollow spokes in each air intake casting is taken a radial shaft driven by bevel gears from the compressor rotor extension shaft. A bevel drive on the ends of these shafts drives the oil and fuel pumps and life recorders.

The parallel-sided stator casing, devoid of stiffening ribs, is a magnesium zirconium alloy casting. Flanges formed on each end allow the casing to be carried from the intake casting at its front end, and it is bolted to the centre section diffuser casing at the rear. Light alloy and stainless steel blades are dove-tailed to carrier rings slotted circumferentially into machined grooves in the stator case. The compressor rotor, carrying ten rotor discs, consists of a parallel-sided M.A.T.101 drum bolted at either end to steel extension shafts. The first compressor stage disc is carried on the forward extension shaft where it is tightened against its register by a ring nut. This first compressor disc of reduced bore and the next three discs mounted on the rotor drum are all of solid construction. The remaining discs are built up from two opposed conical halves. Apart from the tenth and eleventh stages thin wall discs are used, and these built-up discs are riveted on their circumference to the tangs of the rotor blades. Machined into the hub of each disc are locating dogs and axial fit is machined-in.

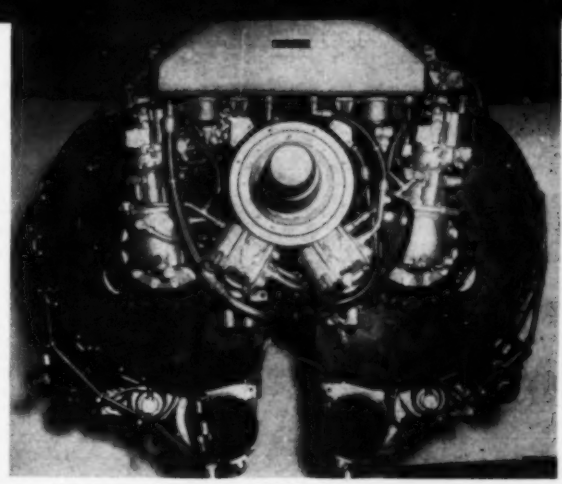
The first four stages of compressor blading were changed from light alloy to steel at an early stage in Mamba development. Stages five to nine are aluminium and the remaining blade stages are of stainless steel. The four rows of steel blades are tanged into the solid discs with longitudinal fir-tree attachments and are locked with pins. The remaining blades are integral, with the tangs riveted between the compressor discs. Between the platforms formed on the base of each blade rotating shrouds are fitted.

Carried by the rear stub of the compressor drum is the inner member of a labyrinth seal. The mating static member fits into a register on the centre casing in line with the straightener blades.

The entire end-thrust of the rotative assembly is carried by the front main bearing. This is a heavy-duty ball bearing with the centre race split into two halves to permit the use of the largest possible number and diameter of balls. The centre main bearing, carried by the light alloy centre section, is a single-row parallel-roller bearing supporting journal loads only. Cast within the centre section are the diffuser passages, and the rear face of the casting carries a semi-cantilevered forged tubular centre-section extension. This casting terminates in a flange to which is bolted a cylindrical iron casting carrying the rear main bearing.

Lubrication is by flood feed from a gear-type pressure pump, passed through filters to a distribution chamber, and from there by drillings or piping to the bearings, throttle delay servo box, anticipator unit and propeller controller.

The shafting connecting the turbine and compressor assemblies is in five sections: the compressor rear extension shaft, the turbine mainshaft, a tapered turbine front extension shaft and the turbine stub shaft. The latter, which is carried in the rear main bearing, is splined to the turbine extension shaft and locked with a ringnut. The turbine extension shaft is bolted in turn to the mainshaft tube which drives the compressor extension shaft through a gear-type coupling and spherical self-aligning bush.



The ASMD.8 head-on; frontal area is modest for a 3,600 s.h.p. twin. Blanking plates are fitted over the intakes.

The annular vaporizing combustion chamber follows usual Armstrong Siddeley practice; it comprises an inner and outer gas-tight annular casing, inner and outer annular flame tubes and a flat circular support plate bearing the vaporizers.

Provision for lighting-up is made by conventional high-energy igniters and Ki-gass primers pressurized by an electric fuel pump. The turbine outer casing is a parallel-sided thin-wall tube welded to flanges at either end and bolted at the rear to the combustion chamber outer casing and at the rear to the exhaust cone. The first-stage nozzle blades are bolted directly to carrier rings cantilevered from the combustion chamber flange, and the two stages of stators are carried between channel section rings, the rearmost of which is dogged to the casing flange to prevent rotation and to allow for differential expansion. Nozzle and stator blades have integral shrouds formed at their tips, and on to an internal flange on the stator shrouds is riveted a diaphragm plate which forms the static part of the inter-stage labyrinth seal.

The three discs of the turbine rotative assembly are located by Hirth couplings between the front disc and the flange of the turbine stub shaft, the shaft and the second disc, and between the second and third discs. The first stage rotor blades (Nimonic 100) are plain, but the blades on the second (Nimonic 100) and third (Nimonic 80A) stages have integral shrouds; all are secured to the discs with helical fir-tree serrations, and are locked by longitudinal strips. The discs are cooled by air tapped from the final compressor stage which, being at high pressure, can flow up the faces of the discs to join the main stream. Eleventh stage air is used also as a thrust equaliser to relieve bearing thrust loads.

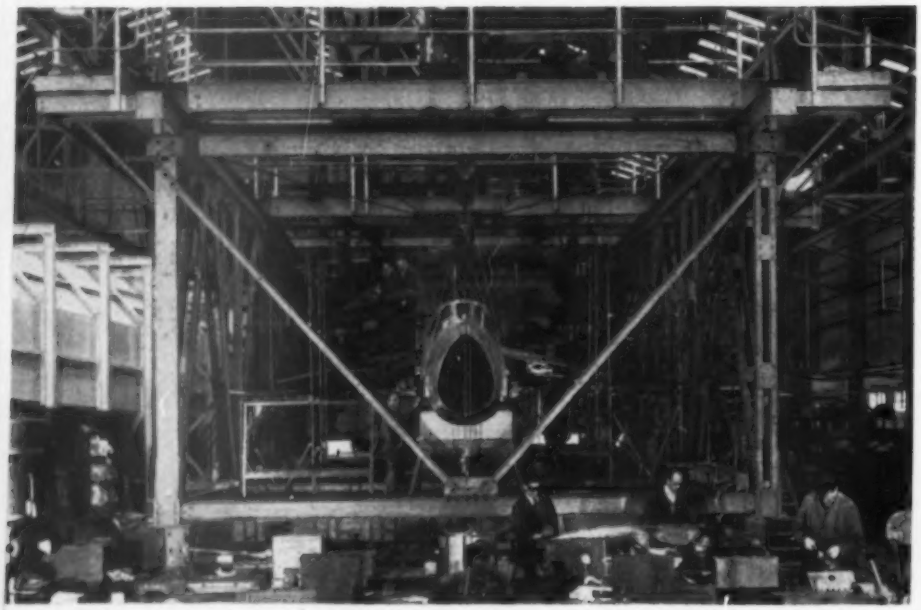
The exhaust cones are conventional, but the inner cone is supported by stay bolts shrouded by aerofoil section struts and precision-cast collars and sleeves are welded to these bars and to the skin. Aerofoils are cambered to bring them into line with the jet efflux swirl—which allows an increase of pressure ratio.

The Double Mamba ASMD.8 is rated in an unusual way. Instead of ratings for take-off, intermediate and maximum continuous cruising power, only one rating is employed. Hence, the take-off power available is not twice the 1,950 s.h.p. of the Mamba 8 but $2 \times 1{,}800$ s.h.p. This is a nominal power that represents a higher continuous cruising power than would have been granted if 1,950 s.h.p. per side had been quoted as maximum.

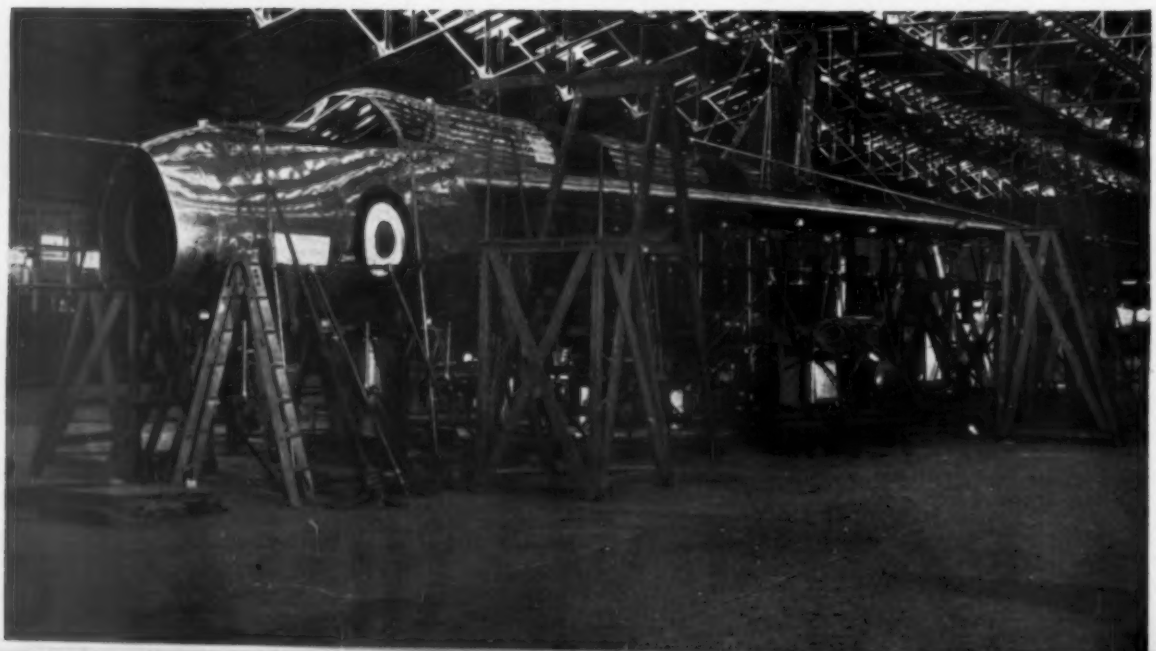
The Double Mamba 8 went into production early this month and will soon be officially type tested. The engine in this form probably represents the ultimate in a long line of Mamba engine development since, with the turbine already making use of advanced materials, a considerable mechanical re-design would be required to extend the stretch process any further. A double engine based on the power available from the ASM.1 would have given 1.960 s.h.p., whereas the present engine has the brochure power of 3,600 s.h.p.—a figure which has been more than equalled in development. This engine is now being flight-tested from Bitterswell in a standard Gannet 1, a rather odd-looking aeroplane, since the exhaust pipes of the raised engine are brought out below and in front of the leading edges. The Double Mamba could possibly make an attractive power unit for installation within the wing of a civil aircraft. But this is largely a pipe dream; the most profitable fruit of eleven years of Mamba and Double Mamba experience, Armstrong Siddeley say, will be in the P.182 engine, the design of which in its final form, is now well advanced.

PROVING THE P.1

Static Testing by English Electric



FEW would challenge the contention that the P.1 intercepter for the R.A.F. is the subject of the largest aircraft-development programme in this country today. The English Electric Company hold prime responsibility for the complete P.1 weapon system and they are being assisted by Ferranti (who have been named as the principal supplier of the radar equipment) and many other firms, including Rolls-Royce and D.H. Propellers. The flight testing of the P.1 has been extensively reported, notably in our issues of April 26 and July 19. It is now permissible to publish photographs of some of the static testing which has been—and still is—a major part of the overall effort. The two pictures above show static firing of a de Havilland Propellers Firestreak from the port pylon of a P.1B fuselage section which has been mounted on its side at R.A.F. Valley, Isle of Anglesey. Portions of the body, ventral tank and tailplane are provided with blast detectors and temperature sensers. The picture on the left shows the third P.1A (structural-test) aircraft in its combined wing and fuselage loading rig and the illustration below depicts a P.1A undergoing vibration testing. Nearly all the ground testing of the P.1 is being undertaken by English Electric's aircraft research and development centre at Warton Aerodrome, Lancashire.



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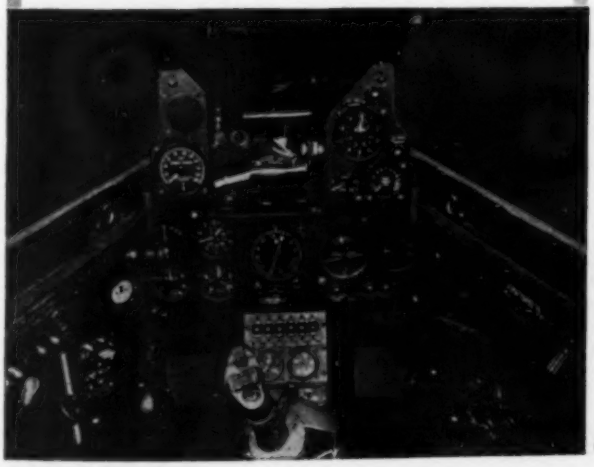
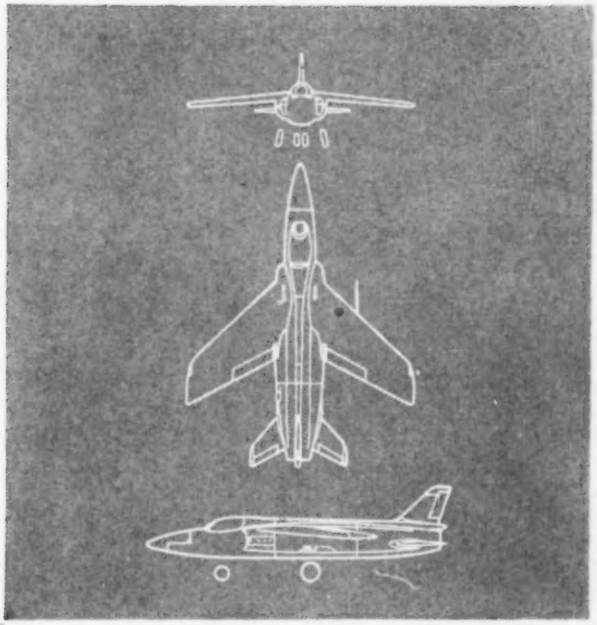


Cockpit of the Folland Gnat



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A Blackburn-built Sopwith Baby.

HISTORIC MILITARY AIRCRAFT No. 17

PART III

By J. M. BRUCE, M.A.

The Sopwith Tabloid, Schneider and Baby

THE Clerget-powered version of the Sopwith single-seat seaplane had first appeared in September 1915. The first to have the new engine was probably No. 8123, and most of the remainder of the batch 8118-8217 had the Clerget. As the war progressed, the Schneiders had acquired additional equipment and their performance began to suffer in consequence.

As a palliative, the more powerful Clerget was therefore substituted for the Monosoupape, and with its installation the frontal aspect of the aircraft altered. Gone were the bull-nose cowling and fore-and-aft mounting, for the Clerget was carried on an overhung mounting and had an open-fronted cowling.

The modified aircraft became known as the Sopwith Baby, but the name Schneider persisted in use and was occasionally used to describe both Schneiders and Babies. Naturally, these loose designations have led to some confusion over the precise identity of the type concerned in various exploits.

Armament varied considerably. Many Babies retained the centre-section mounting for the Lewis gun, on which the gun was inclined upwards at roughly 20 deg to fire over the propeller. This was reasonable enough against targets the size of Zeppelins, but the installation was useless for combat. A fair number of Babies had a synchronized Lewis gun fixed on top of the fuselage and firing forward through the propeller arc, the standard position being central; but on No. 8151 the gun was mounted on the starboard upper longeron. On this aircraft the Lewis gun retained its jacket. No. 8160 had a Lewis gun mounted on its side but pointing upwards at 45 deg through the centre section: the gun butt was stayed to the port rear centre-section strut and the barrel apparently rested against the front spar of the centre section. Yet another machine (which had a four-bladed propeller) had twin Lewis guns wholly above the centre section, firing straight ahead above the propeller.

The upward angle of several of these installations was, of course, occasioned by the Baby's employment as an anti-airship aircraft. For similar duties, at least one Baby was experimentally fitted with Le Prieur rockets of the type developed by a French naval officer, Lt. Y. P. G. Le Prieur, specifically for use against lighter-than-air craft. The Baby in question had launching tubes for ten rockets, five on each pair of interplane struts, and their firing was quite a picturesque affair. Rockets did not become standard equipment for the Sopwith Baby, but a number of Sopwith Pups were fitted with rocket tubes; so also was the prototype Sopwith 2F.1 Camel, N.5, when it first appeared.

The Baby was distributed in the same way as its predecessor, the Schneider, and was called upon to perform the same wide range of duties from coastal stations and various ships. The first official mention of Babies in action occurs in the account of the attempted raid on Hoyer, Schleswig-Holstein, where an enemy airship base was believed to be situated. Two Babies and three Short 184s were taken across the North Sea aboard H.M.S. *Vindex*, a former Isle of Man passenger steamer which had been converted into a seaplane carrier. All available ships of the Harwich force and the Battle Cruiser Fleet sailed in support of the little 2,900-ton carrier. When well inside the Vyl light vessel on March 25, 1916, *Vindex* got her seaplanes away at 5.30 a.m. The weather was bad and the raid unsuccessful; two of the Shorts and Baby No. 8152 (pilot, F/L. J. F. Hay) were lost, and the joint adventures of the crews of one of the Shorts and the Baby are a story in themselves.*

Information supplied by Mr. Bruce Robertson and material lent by Mr. A. R. Weyl, A.F.R.Ae.S., A.F.I.A.S., F.B.I.S., has contributed substantially to this history, and the author wishes gratefully to acknowledge their assistance.

This action served to establish that the airship base was not at Hoyer, but a few miles inland at Tondern. A further attempt to bomb this target was made, but with the principal object of inducing the German High Sea Fleet to put to sea. This time, all the aircraft were Sopwith Babies, and soon after 3 a.m. on May 4, 1916, *Vindex* and *Engadine* hoisted out eleven aircraft off the Island of Sylt. Four broke their propellers, three had engine failure, and one was overturned by the wash of the accompanying destroyers. Of the three which succeeded in taking off, one struck the wireless aerial of the destroyer *Goshawk* and crashed; the second developed engine trouble and had to return after only a short flight; the third, alone of the eleven, reached Tondern, where the target was found to be obscured by mist. The pilot dropped his two 65-lb bombs but saw no results. The raid was a complete failure.

Although the Schneiders and Babies enjoyed the doubtful distinction of figuring in some of the most spectacular débâcles of the war in the air, they nevertheless performed a great deal of unspectacular but valuable work on anti-submarine patrols and as escorts for the two-seat seaplanes. Increasing numbers of German seaplanes made the provision of escorts essential, and on June 24, 1916, four Babies were transferred from H.M.S. *Vindex* to the seaplane station at Dunkerque for that specific purpose. A further nine were allocated in May 1917, but the Babies were superseded by Pups two months later, when the Seaplane Defence Flight was formed at St. Pol.

Another activity in which the Baby gave way to the Pup was that of deck-flying. After H.M.S. *Campania* rejoined the Grand Fleet on April 12, 1916, much encouraging work had been done with her seaplanes. On May 29, five pilots made successful take-offs from the deck in Sopwith Baby seaplanes while *Campania* was steaming at about 20 kt; as before, wheeled dollies were placed under their floats. Next day her equipment consisted of three Babies, four Schneiders and three Short 184s, all of which she would have taken to the Battle of Jutland had she received her stationing and timing signal. But she did not receive it, and the only Babies at Jutland were the two aboard *Engadine*; they were not flown.

Another Isle of Man steamer, the *Manxman*, had been commissioned as a seaplane carrier in December 1916, with Short 184s aft for reconnaissance duties and Sopwith Baby seaplanes forward for anti-Zeppelin work. F/L. F. J. Rutland was convinced that the Pup was a better proposition than the Baby: in January 1917 he made the first two take-offs from *Manxman's* deck in a Baby, and demonstrated that a strong wind along the deck was essential to ensure that the aircraft became airborne. His argument was conceded, and the Babies on *Manxman* and *Campania* were replaced by Pups.

As the Baby seaplanes found increasingly extensive use in home

* See *The War in the Air*, Vol II, pages 388-389.

A Sopwith-built Baby with experimental gun installation.

Right, a Baby firing Le Prieur anti-airship rockets.

The Sopwith Tabloid, Schneider and Baby . . .

waters and the Mediterranean it became necessary to expand production. The Sopwith company was heavily committed with production of 1½-Strutters, Pups, Triplanes and the development of the Camel; consequently all later contracts for Baby seaplanes were given to other contractors.

The first manufacturer to receive a contract for Babies was the Blackburn Aeroplane and Motor Co., Ltd., of Leeds. Although the Blackburn-built machines were externally indistinguishable from those built by Sopwith, there may have been structural differences, perhaps accounting for the otherwise curious fact that an aircraft existed which was in effect a prototype Blackburn-built Baby. This was N.300, which apparently was to have been the first of a new Admiralty series of prototypes, parallel to the series which began at N.1 and N.500. Baby N.300 had a 110 h.p. Clerget and, after completion of its trials, was sent to H.M.S. *Campania* as part of the carrier's aircraft complement on February 10, 1917. It survived until May 11, 1918, when it was written off, after fair wear and tear, at Scapa Flow.

By the time N.300 joined *Campania*, other Blackburn-built Babies (still with the 110 h.p. Clerget) were in service, and had entered upon the strenuous duties which were the lot of the little Sopwith seaplanes. They were severely taxed by their war-load which, in addition to fuel and oil for 2½ hours, included a Lewis gun and ammunition, two 65-lb or one 112-lb bomb, carrier pigeon, emergency rations and a sea anchor.

An intelligent attempt to improve this state of affairs was made in a variant of the Sopwith Baby which was built by the Fairey Aviation Co., Ltd. On October 23, 1916, the Sopwith Baby No. 8134 was sent to the Fairey works for repair, and the opportunity was taken to rebuild the aircraft to incorporate a number of modifications. Of these, the most significant was the Fairey Patent Camber Gear, which was a form of trailing-edge flap intended to increase lift. On the Fairey-built aircraft the entire trailing portion of each mainplane was hinged along the rear spar and could be progressively lowered by rotating a handwheel in the cockpit. A differential device ensured that the flaps could still be actuated as ailerons; thus lateral control was maintained and was reasonably effective down to the stall. The machine in this modified form was known as the Fairey Hamble Baby.

The precise form of No. 8134 when rebuilt is not known, but the production Hamble Babies differed considerably in appearance from the machines built by Sopwith and Blackburn. The plan-form of wings and tailplane were changed: the mainplanes, which were of increased span and reduced chord, had rounded tips, and the tailplane had a characteristic shape somewhat different from the roughly semi-circular outline of the Sopwith original. A new and angular fin, Fairey-designed main floats of new form, and an enlarged tail float were fitted, and the engine cowling was of modified contours. The fuselage appeared to be similar to that of the Sopwith Baby; it was made in two parts which were joined a short distance behind the cockpit. The engine of the prototype and early production machines was still the 110 h.p. Clerget.

The Hamble Baby was tested by Sqn. Cdr. Maurice Wright, and the type went into production, both at the Fairey works and at the Bristol factory of Parnall and Sons. A standard Sopwith-built Baby (No. 8194) had been sent to the Parnall works in January 1917, doubtless to allow the firm to acquaint themselves with the construction of the aircraft. In the event, the majority of Hamble Babies were built by the Parnall company, but their products differed slightly from the Fairey-built Hamble Babies. The Parnall-built machines retained the Sopwith-type fin and rudder, Sopwith main floats, and, apparently, the Sopwith-style engine cowling. It seems, however, that there were other differences, differences likely to add to the worries of the equipment officers of the time, for Admiralty Letter Air 12930 of August 15, 1917, stated:

"Spares: In view of the difference in design of the Hamble Baby seaplanes constructed by Messrs. Fairey and Messrs. Parnall, stations demanding spare parts for these machines should quote the maker of the machines in each case."

Standardization had not, it seems, been attained by 1917.

The remainder of the Admiralty letter is worth quoting in full, for it gives an interesting insight into the handling of the Hamble Baby and the use of the flaps.

"Adjustable Wing Flaps: For normal flying, i.e., for getting off the water, climbing, turning and landing with full war load, i.e., two 65-lb bombs, guns, etc., the flaps should have a depression of 1¼in measured from the trailing edge of the centre section to the trailing edge of the flap.

"Machines which have an angle of incidence of 5 deg on the mainplanes for normal flying require the handle adjusting the flaps to be turned 33 times from the bottom, and those which have an angle of incidence of 2½ deg will require 22 turns to obtain this depression.

"This may vary slightly with different machines; extreme angles of depression or elevation are not advisable as the fore and aft and lateral control, when hard down, become very inefficient.

"When the machine does not carry bombs the flaps should be retained in a normal position for getting off and landing.

"Pilots flying these machines, until they have had considerable experience, should be warned that large alterations to the flaps should only be made when well into the air and not before rising from the water."

From that document it appears that the angle of incidence could be either 5 deg or 2 deg 30 min: an official Air Board drawing of the Parnall-built Hamble Baby quotes only the latter value, however. It will also be noted that full depression of the flaps had an adverse effect upon both longitudinal and lateral control. The former is not surprising, but of the latter Oliver Stewart has recorded: ". . . the ailerons extended for the entire length of the wings. In consequence of this the controls were heavy, but they gave good results at low speeds right down to the stall."

Production Hamble Babies became available in the spring of 1917, and the first Parnall-built machine, N.1190, underwent official trials on May 10. This machine may have been used for experimental purposes, for an official document dated November 14, 1917, contains a record of a special float or floats being fitted to (or at least designed for) N.1190. Each float was 13ft 1in long and 1ft 11½in in beam, weighed 122 lb and had a displacement of 1,550 lb. The experimental floats were built by S. E. Saunders, Ltd., but the outcome of the trials (if indeed any were conducted) is unknown. The size of these floats seems to indicate that it might have been intended to dispense with a tail float.

In spite of all these improvements in the basic Sopwith design, the Service demands for better performance continued unabated; and it was therefore decided to install the 130 h.p. Clerget engine in the Baby seaplanes. At the time when that decision was reached, the Sopwith company had commitments which were heavier than ever, for the Camel was in large-scale production and several new designs were being developed. The re-design and modification of the Baby airframe were therefore left to the Blackburn and Fairey companies; presumably the latter firm advised Parnall as necessary.

The first Blackburn-built Baby to have the 130 h.p. engine was N.1019, and all production machines from N.1410 onwards were so powered. For the batch N.1410-N.1449 the use of the 150 h.p. A.R.1 engine was contemplated, but there is no known record that such an installation was in fact made. The 130 h.p. Blackburn-built Baby was occasionally known as the Blackburn Baby.

In the case of the Fairey Hamble Baby, the new engine was apparently introduced on later production machines, and there are indications that the last ten of the batch N.1320-N.1339 had the 130 h.p. Clerget. All subsequent Hamble Babies had the more powerful engine. The first Parnall-built Hamble Babies were fitted with the 110 h.p. Clerget, but most of them had the 130 h.p. engine.

[*To be continued*

Errata: Two printing errors occurred in Part I of this article (November 8): the reference to "No. 60 Sopwith Scout" should have read "No. 6 Sopwith Scout"; and the date at which Tabloid No. 1208 was at Great Yarmouth should have read "mid-May 1915", not 1914.

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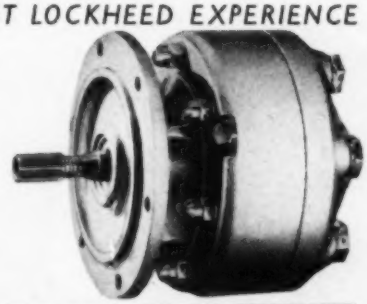

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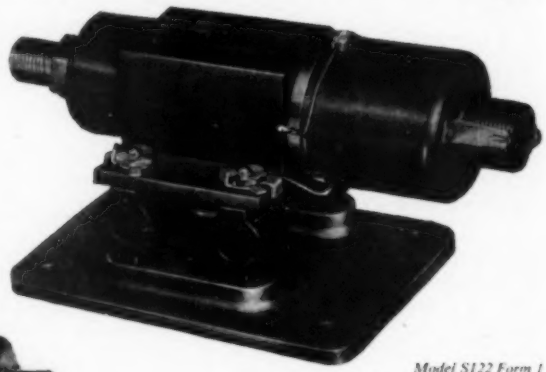
On the Double Mamba Mark 112 engine two Form 1 Transmitters are fitted to indicate oil pressures and two Form 4 Transmitters are used with associated Weston indicators calibrated in shaft horse-power.



Model S122 Form 1 Medium Pressure Transmitter. Available with A. V. Mounting as shown or for direct mounting.

Model S122 Form 4 High Pressure Transmitter. Supplied with or without A. V. Mounts.

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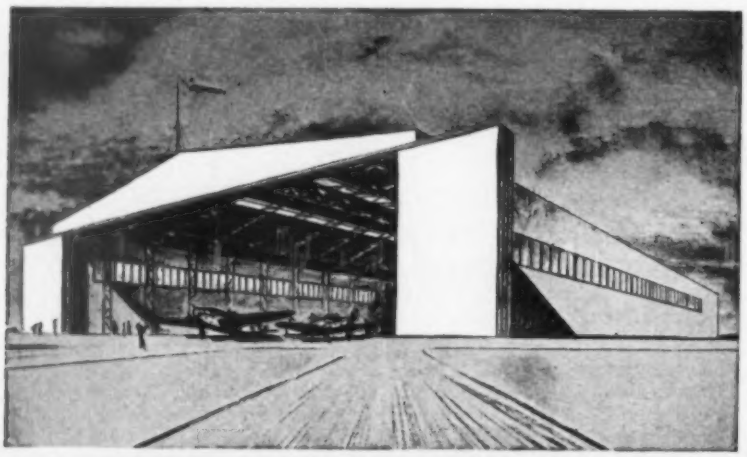

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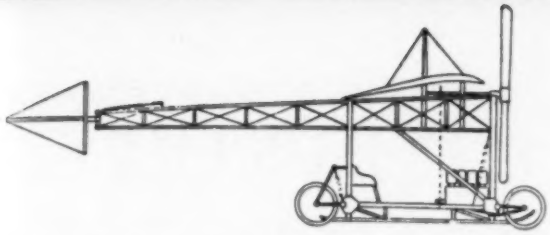


The Blackburn catalogue illustration referred to by Mr. M. G. K. Byrne. Accompanying text included the statement that "The centre of gravity is very low, thereby making the aeroplane very stable at high speeds." Speed is given as 60 m.p.h.

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

Air/Sea Rescue Searches

MANY readers must have been distressed to note the ease with which a pilot who decides to bale out of his aircraft around the coasts of Britain can seemingly vanish completely. Although I am not in possession of any facts other than those published by the national Press, I think it worthy of comment that a U.S.A.F. lieutenant and an unnamed pilot from the Hunter O.C.U. at Chivenor should—within a week of each other—both be lost to the sea after leaving their aircraft only a few miles from the English shore. I had thought that the Sarah miniature radio transmitter and other devices had removed for all time the tragedy and anguish of a search being abandoned.

London, W.C.2. W. MILLER.

Early Catalogues

"HISTORIAN," who has dug up Humber's 1910 catalogue, may care to call in here one day and look at "The First Aviation Catalogue" (so called) issued by The Aeroplane Supply Co. of 110 Piccadilly. This is dated November 1, 1909, and has some sixty pages.

London, W.1. F. H. SMITH,
Librarian, the Royal Aeronautical Society.

WITH reference to the letter from "Historian" in your issue dated November 8, this company possess a sales catalogue of the same vintage, namely 1910. The first aircraft built by Mr. Robert Blackburn is listed at a price of £700, as shown in the accompanying illustration from the catalogue. The other aircraft, which was named the "slow type," sold for £550 and it had been intended to fly it at the Blackpool Meeting of 1910. Unfortunately, the 35 h.p. Isaacson Radial engine was not ready in time.

In addition, the catalogue lists Blackburn propellers from 5ft diameter (£8 15s) to 10ft diameter (£17 12s) and adds the footnote that propellers of large diameter were available at the rate of £1 15s per foot. Other items listed include an "automatic control for stability" which cost £6 and a "triple steering column," which operated the elevator, rudder and warped the wings, for £10.

At the back of the book there are price-lists for hangars, wheels, ball bearings, radiators, tanks, wire strainers, fabric, etc. The price of steel tubing, 1in diameter, 20-gauge, was 5d per foot, and aluminium sheet in the same gauge was 1s 7d per lb. Wire strainers 5in long were 18s 6d a dozen and a 24in diameter wheel cost £2 15s.

Brough, E. Yorks. M. G. K. BYRNE,
Publicity Manager, Blackburn and General Aircraft, Ltd.

Pinecastle Postscript

ON hearing Air Chief Marshal Sir Harry Broadhurst, A.O.C-in-C., Bomber Command, defend the R.A.F. for placing 27th and 44th in a field of 45 in the Joint U.S.A.F.-R.A.F. bombing competition ("The Vulcans could operate higher than any United States bomber. This was a handicap in the competitions, he added, because the crews had to bomb from 30,000ft, much lower than they were used to."—*The Times*, November 9, 1957):—

Our bombing is better; it always has been,
We've done it for years and the USAF is green.
We've bombed through the clouds and the flak and the night
And we've done it without any super-bombsight.
We've done it from high and we've done it from far,
We've done it by fix on the flickering North star.
But down at Pinecastle we lost all our bets.
The closer the target, the harder it gets.

The USAF dropped bombs from a mere thirty-thou.,
While the Vulcans are working at twice that height now.
And we flew just as fast with our jets in thick wings
As the USAF thin-wing jobs with external things.
When results were announced we were staggered to find
We had placed next to last; but don't take it unkind.
Just say with us loudly, so no one forgets:
The closer the target, the harder it gets.

Geneva. D. A. A.

"The Fighting Fifth"

THAT in replying to Ernest Smithers' mild and courteous reproof (*Flight*, November 8) your contributor, John Yoxall, had not the grace to admit his error in appropriating the traditional sobriquet of an old regiment to a newer formation may be deplored; but that he should have seen fit to be sarcastically libellous at that regiment's expense will give the gravest offence to decent members of all Services and not only to the officers and other ranks, past and present, of Her Majesty's Fifth Regiment of Foot. And it is to be hoped that an unqualified apology will be made without delay.

London, S.W.1. MOONRAKER.

[Our contributor gives his assurance that it was never his intention to be either sarcastic or libellous. *Flight* takes this occasion to salute two splendid military formations, both of which have won glory under the sobriquet "The Fighting Fifth."—Ed.]

"TEST FLIGHT 263"

WITH the above title, a new film made by the British Petroleum Company, Ltd., was shown for the first time in London last week. The peg on which the action and narrative are hung is a routine test flight of a Fairey F.D.2 from R.A.E. Bedford, during which control behaviour is to be investigated at speeds between Mach 1.8 and 2.0 (*sic*). The main content of the film concerns itself with the initial and background effort involved in the design and operation of a modern, high-performance aircraft.

Near the start of the film, the commentary triggers a keen anticipation for an exceptional level of imaginative film writing: "The pundits prattle and mathematicians, grumbling gently, curl up their digits and pass on. . . . The world shrinks. Man and machine are alone; and we stand in head-bowed, humble attitude at his audacity. . . ." The promise is not quite realized, however, in spite of the general high quality and one distinctly Milk-Woodish sequence of hyphenated adjectives as we "listen to the heart-beat on the stethoscope of science." By the end of the film we have slipped from the style of Dylan Thomas to that of a *Daily Express* leader-writer, as the commentator addresses the F.D.2 pilot; "Our heritage is in your hands. Guard it well, and hand it on to your son for his safe keeping"—whatever that may mean.

The photography, which includes visits to the Bedford wind-tunnels, N.G.T.E. Pyestock, various aircraft and engine manufacturers and the R.A.F. Institute of Aviation Medicine at Farnborough, is careful and of a high standard. The film as a whole is undoubtedly a striking presentation—and would be even better without the strident, stirring-note-striking background music, which we seem to have heard so many times before. In spite of its music, *Test Flight 263* is well worth seeing. It was written and directed by David H. Villiers, and produced by Ronald H. Riley, and it runs for 38 minutes. K. T. O.

FORTHCOMING EVENTS

Nov.	26.	R.Ae.S.: Section Lecture: "Some Aspects of Refrigeration in Supersonic Aircraft," by E. J. Gabbay, A.F.R.Ae.S.
Nov.	27.	British Institution of Radio Engineers: A.G.M.
Nov.	27.	Kronfeld Club: Talk by Wally Wallington.
Nov.	27.	R.Ae.S.: Graduates and Students Section: "Flight-Testing Procedures at Supersonic Speeds," by W/C. R. P. Beamont, D.S.O., O.B.E., D.F.C.
Nov.	29.	R.Ae.S.: Graduates and Students Section: Annual Dance.
Dec.	3.	R.Ae.S.: Section Lecture: "Some Techniques of Engine Testing under Simulated Icing Conditions," by O. R. Ballard, A.F.R.Ae.S., and P. J. Sharp.
Dec.	4.	Kronfeld Club: Film Show.
Dec.	6.	Helicopter Association: "The Digital Computer as a Helicopter Flight Simulator," by J. M. Harrison, A.F.R.Ae.S.
Dec.	10.	R.Ae.S.: Graduates and Students Section: Film Show.

R.Ae.S. Branch Lectures (to Dec. 5):—

Nov. 27, *Hatfield*, "Experiences of an Airline Pilot," by Capt. O. P. Jones. Nov. 28, *Bristol*, Junior Members' Paper Competition; *Halton*, Film Show. Dec. 3, *Boscombe Down*, "The Weapon System Concept," by H. Davies. Dec. 4, *Bristol*, "Automation," by J. Sargrove; *Leicester*, "The Economic Basis for the Design of a Freight Aircraft," by A. H. Stratford. Dec. 5, *Cambridge* "Development of the P.1," by F. W. Page.

THE INDUSTRY

Microcell triple-unit airliner seating, referred to in a news-item at the top of Col. 2; the nearest seat is shown in the fully reclining position. The type is known as the T-34 in conformity with airline practice, whereby T stands for tourist and 34 indicates the seat pitch in inches.

New Temperature-resistant Steel

AN important new steel for high-frictional-temperature applications in aircraft and missiles—and for appropriate industrial uses—is announced by Firth-Vickers Stainless Steels, Ltd., of Sheffield. Known as F.V. 520, it is noteworthy in that it is the only type of austenitic stainless steel which can be hardened by low-temperature heat treatment.

Principal characteristics of the new material include high tensile strength and fatigue resistance; "stainless" properties equivalent to those of 18/8 steels; resistance to stress corrosion cracking; high resistance to notched impact loads at sub-zero temperatures; weldability; thermal expansion equivalent to that of mild steel; and, last but not least, a 500 deg C ceiling temperature for service.

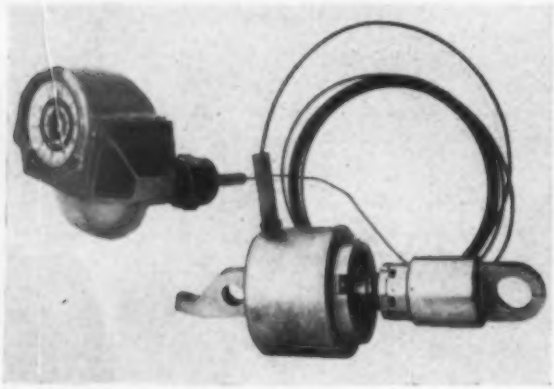
It is stated that test samples immersed in sodium chloride for a year were practically unaffected, and that other laboratory tests have shown F.V. 520 to be "superior to all other types of stainless steel." Unlike the majority of stainless steels capable of being heat-treated to a relatively high tensile-strength, F.V. 520 can be readily welded without pre-heating. No elaborate precautions are needed to avoid cracks and there is no tendency to peak hardening in the heat-affected zones. Maximum hardness adjacent to welds is of the order of 320 Brinell. No heat treatment after welding is needed, although a post-weld treatment at 550 deg C may be considered desirable for purposes of stress relief.

F.V. 520 was developed by Mr. John Morley, chief metallurgist of Firth-Vickers.

Other news from Firth-Vickers is of the completion of two new documentary films dealing with the company's work. One, *The Manipulation of Corrosion and Heat-resisting Steels*, is of an essentially practical nature for the guidance of users; the other, *Where "Staybrite" Steels are Made*, is of a more general nature, depicting a tour of all departments of the company's main works. Both films, which are 16 mm Kodachrome with sound commentary, may be hired free of charge by responsible persons on application to Firth-Vickers Stainless Steels, Ltd., Staybrite Works, Sheffield, 9.

"Aeroweb" Honeycomb

THE honeycomb material produced by Aero Research, Ltd., Duxford, Cambs, is in future to be marketed under the registered trade name Aeroweb. Aeroweb metal honeycomb core is used in conjunction with Redux adhesive in film form for—among other applications—sandwich panels for aircraft. It is suitable for flat surfaces of constant or tapering thickness as well as for shapes involving single or double curvature. Aeroweb honeycomb is supplied in thicknesses up to 9in, in cell sizes of $\frac{1}{8}$in, $\frac{1}{4}$in and $\frac{3}{8}$in inscribed circle, and in various foil thicknesses.



Developed in conjunction with Alltools, Ltd., by Mr. F. S. Saunders, of the B.O.A.C. Engineering Group, this capillary-type jet thrustmeter is one of the first designed for airborne use actually to measure the load at the engine trunnions. Two are flying in an M.o.S. research machine.

High-density Seating

A NEW type of airliner high-density seating, known as the Microcell T-34, has been devised by the aircraft division of Microcell, Ltd., 56 Kingsway, London, W.C.2. The pitch is 34in, and the triple seat unit weighs a total of 75 lb. Each back is separately adjustable for reclining; tip-up seats and intermediate tip-up arm-rests are fitted; and on the seat-backs there are meal-trays of the hinged variety, while provision is also made for the plug-in type of tray.

Neoprene in the U.K.

IN accordance with a decision to manufacture neoprene in the United Kingdom, modifications have been made in existing distribution arrangements. The Du Pont Co. (United Kingdom), Ltd., with offices at 5 Charles II Street, London, S.W.1, has been formed to manufacture and sell neoprene in the United Kingdom and European markets. This company is a wholly owned subsidiary of E. I. Du Pont de Nemours and Co. Inc. With effect from January 1 next, sales of neoprene will be made in the name of Du Pont Co. (United Kingdom), Ltd., and Durham Raw Materials, Ltd., will act as sales agents. From the same date the latter company will surrender the agency and Du Pont Company (United Kingdom), Ltd., will assume full control of all neoprene sales.

IN BRIEF

Helicopter Sales, Ltd., formerly at Hunton Bridge, King's Langley, Herts, have changed their address to 14 Woodlands Parade, High Street, Watford (tel. Watford 2089 and 2998).

* * *

Black and Decker, Ltd., announce the appointment of Mr. Douglas Brown as marketing manager. During the war Mr. Brown served in Bomber Command, attaining the rank of squadron leader, and was awarded the D.F.C. as a navigator in the Pathfinder Force.

* * *

Decca Type 424 airfield control radar has been installed by Rolls-Royce, Ltd., at their flight test airfield at Hucknall. Used for precision talk-down and local-area surveillance, the equipment ensures that test-flying programmes are interrupted as little as possible by adverse weather conditions.

* * *

Mr. Charles Purley, chairman of Lec Refrigeration, Ltd., left London on November 9 for the U.S.A. and Canada. His three-week tour will include a visit to the air-conditioning and refrigeration exhibition being held in Chicago, and he is accompanied by Mr. R. H. Wall, head of the company's work-study department.

* * *

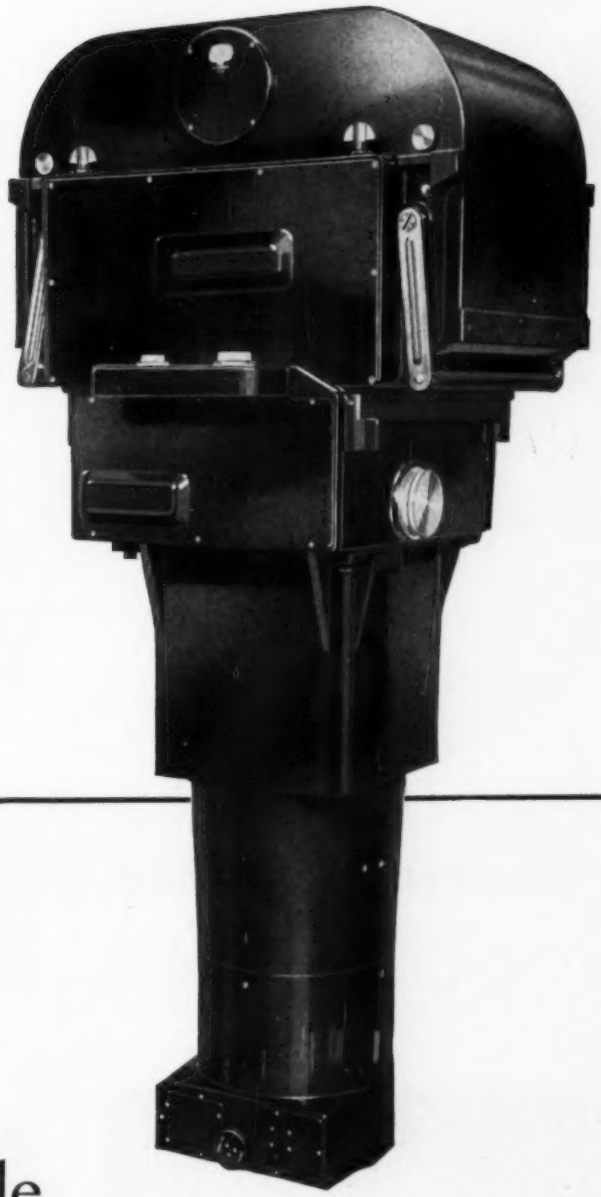
Mr. Miles Beevor has joined the Board of Rubery, Owen and Co., Ltd., the parent firm of the Owen Organization, at the invitation of the chairman, Mr. A. G. B. Owen. Mr. Beevor, who served in the R.A.F.V.R. from 1941-43, became managing director of the Brush Group in October 1952 and was subsequently deputy chairman of the Group until its merger with Hawker Siddeley in June this year.

* * *

The analytical department of Short Brothers and Harland, Ltd., Belfast, is now offering to industry a computing service. Using a battery of four Short general-purpose analogue computers and a newly installed English Electric Deuce digital computer, the department will make the service generally available on a fixed rental basis. In addition to the computers, the department—which is headed by Mr. J. J. Foody—makes use of Hollerith recording and data-handling equipment.

* * *

Four boom-type vehicles recently delivered to the South African Air Force for fuelling Sabres are of the diesel-engined Leyland Hippo six-wheel type, modified to British M.o.S. specifications. Zwicky pumping and filtration equipment is incorporated and the tanks—built by Duncan, Andrew Engineers (Pty), Ltd., of Johannesburg—are of 2,500 gal capacity each. It is stated that with both pumps in use, one of these vehicles is able to put 700 gal of kerosine into the tanks of two Sabres in less than five minutes.



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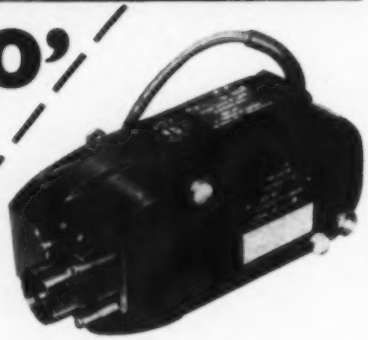

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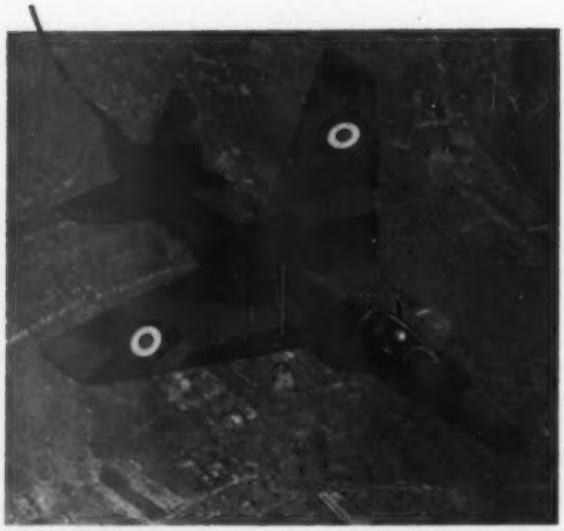

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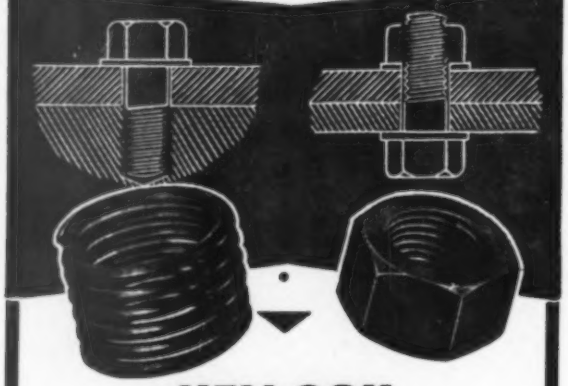

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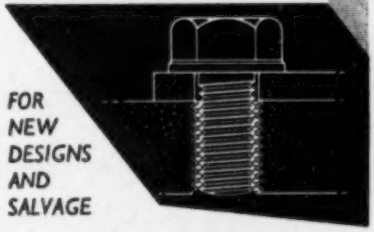

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